JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1913.

(INCORPORATED 1881.)

VOL. XLVII.

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH, SYDNEY.
LONDON AGENTS:
GEORGE ROBERTSON & Co., PROPRIETARY LIMITED,
17 WARWICK SQUARE, PATERNOSTER ROW, LONDON, E.C.

1913.

NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations, are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. $\times$ $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

Vol.	I.	Transactions of the Royal Society, N.S.W.,					1867,	pp. 83,	,,
,,	II.	,,	,,	,,	,,	,,	1868,	,, 120,	,,
,,	III.	,,	,,	,,	,,	,,	1869,	,, 173,	,,
,,	IV.	,,	,,	,,	,,	,,	1870,	,, 106,	,,
,,	V.	,,	,,	,,	,,	,,	1871,	,, 72,	,,
,,	VI.	,,	,,	,,	,,	,,	1872,	,, 123,	,,
,,	VII.	,,	,,	,,	,,	,,	1873,	,, 182,	,,
,,	VIII.	,,	,,	,,	,,	,,	1874,	,, 116,	,,
,,	IX.	,,	,,	,,	,,	,,	1875,	,, 235,	,,
,,	X.	Journal and Proceedings			,,	,,	1876,	,, 333,	,,
,,	XI.	,,	,,	,,	,,	,,	1877,	,, 305,	,,
,,	XII.	,,	,,	,,	,,	,,	1878,	,, 324,	price 10s. 6d.
,,	XIII.	,,	,,	,,	,,	,,	1879,	,, 255,	,,
,,	XIV.	,,	,,	,,	,,	,,	1880,	,, 391,	,,
,,	XV.	,,	,,	,,	,,	,,	1881,	,, 440,	,,
,,	XVI.	,,	,,	,,	,,	,,	1882,	,, 327,	,,
,,	XVII.	,,	,,	,,	,,	,,	1883,	,, 324,	,,
,,	XVIII.	,,	,,	,,	,,	,,	1884,	,, 224,	,,
,,	XIX.	,,	,,	,,	,,	,,	1885,	,, 240,	,,
,,	XX.	,,	,,	,,	,,	,,	1886,	,, 396,	,,
,,	XXI.	,,	,,	,,	,,	,,	1887,	,, 296,	,,
,,	XXII.	,,	,,	,,	,,	,,	1888,	,, 390.	,,
,,	XXIII.	,,	,,	,,	,,	,,	1889,	,, 534,	,,
,,	XXIV.	,,	,,	,,	,,	,,	1890,	,, 290,	,,
,,	XXV.	,,	,,	,,	,,	,,	1891,	,, 348,	,,
,,	XXVI.	,,	,,	,,	,,	,,	1892,	,, 426,	,,
,,	XXVII.	,,	,,	,,	,,	,,	1893,	,, 530,	,,
,,	XXVIII.	,,	,,	,,	,,	,,	1894,	,, 368,	,,
,,	XXIX.	,,	,,	,,	,,	,,	1895,	,, 600,	,,
,,	XXX.	,,	,,	,,	,,	,,	1896,	,, 568,	,,
,,	XXXI.	,,	,,	,,	,,	,,	1897,	,, 626,	,,
,,	XXXII.	,,	,,	,,	,,	,,	1898,	,, 476,	,,
,,	XXXIII.	,,	,,	,,	,,	,,	1899,	,, 400,	,,
,,	XXXIV.	,,	,,	,,	,,	,,	1900,	,, 484,	,,
,,	XXXV.	,,	,,	,,	,,	,,	1901,	,, 581,	,,
,,	XXXVI.	,,	,,	,,	,,	,,	1902,	,, 531,	,,
,,	XXXVII.	,,	,,	,,	,,	,,	1903,	,, 663,	,,
,,	XXXVIII.	,,	,,	,,	,,	,,	1904,	,, 604,	,,
,,	XXXIX.	,,	,,	,,	,,	,,	1905,	,, 274,	,,
,,	XL.	,,	,,	,,	,,	,,	1906,	,, 368,	,,
,,	XLI.	,,	,,	,,	,,	,,	1907,	,, 377,	,,
,,	XLII.	,,	,,	,,	,,	,,	1908,	,, 593,	,,
,,	XLIII.	,,	,,	,,	,,	,,	1909,	,, 466,	,,
,,	XLIV.	,,	,,	,,	,,	,,	1910,	,, 719,	,,
,,	XLV.	,,	,,	,,	,,	,,	1911	,, 611,	,,
,,	XLVI.	,,	,,	,,	,,	,,	1912	,, 275,	,,
,,	XLVII.	,,	,,	,,	,,	,,	1913	,, 318,	,,

CONTENTS.

VOLUME XLVII.

DATES OF PUBLICATION.

VOLUME XLVII.

Part I—pp. 1 – 112, published September 19, 1913.
,, II—pp. 113 – 247, ,, February 5, 1914.
,, III—pp. i. – xlix., (i. – xxii.) published March 19, 1914.

Royal Society of New South Wales.

OFFICERS FOR 1913-1914.

Patron:

HIS EXCELLENCY THE RIGHT HONOURABLE BARON DENMAN, P.C., G.C.M.G., G.C.V.O., etc.

Governor-General of the Commonwealth of Australia.

Vice-Patron:

HIS EXCELLENCY SIR GERALD STRICKLAND, K.C.M.G.

Governor of the State of New South Wales.

President:

HENRY G. SMITH, F.C.S.

Vice-Presidents:

F. H. QUAIFE, M.A., M.D.

F. B. GUTHRIE, F.I.C., F.C.S.

D. CARMENT, F.I.A., F.F.A.

R. H. CAMBAGE, L.S., F.L.S.

Hon. Treasurer:

H. G. CHAPMAN, M.D.

Hon. Secretaries:

J. H. MAIDEN, F.L.S.

Prof. POLLOCK, D.SC.

Members of Council:

J. B. CLELAND, M.D., CH.M.

Prof. T. W. E. DAVID, C.M.G., B.A., D.SC., F.R.S.

W. S. DUN.

R. GREIG-SMITH, D.SC.

W. M. HAMLET, F.I.C., F.C.S.

C. HEDLEY, F.L.S.

T. H. HOUGHTON, M. INST. C.E.

C. A. SUSSMILCH, F.G.S.

H. D. WALSH, B.A.I., M. INST. C.E.

Prof. W. H. WARREN, LL.D.

FORM OF BEQUEST.

I bequeath the sum of £ to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., CH.M., Macquarie-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1877	P 5	Abbott, W. E., 'Abbotsford,' Wingen.
1904		Adams, William John, M. I. MECH. E., 175 Clarence-street.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ld., Cement Works, Granville.
1905		Anderson, Charles, M.A., D.SC. *Edin.*, Australian Museum, College-street.
1909	P 6	Andrews, E. C., B.A., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1878		Backhouse, His Honour Judge A. P., M.A., 'Melita,' Elizabeth Bay.
1894	P 19	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1896		Barff, H. E., M.A., Registrar, The University of Sydney.
1908	P 1	Barling, John, 'St. Adrians,' Raglan-street, Mosman.
1895	P 9	Barraclough, S. Henry, B.E., M.M.E., ASSOC. M. INST. C.E., M. I. MECH. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Lecturer in Mechanical Engineering in the University of Sydney; p.r. 'Marmion,' Victoria-street, Lewisham.
1906		Basnett, Nathaniel James, Accountant, Punch-st., Mosman.
1894		Baxter, William Howe, Chief Surveyor, Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1900		Bender, Ferdinand, Accountant and Auditor, 114 Hunter-st.
1909		Benson, William Noel, B.SC., Emmanuel College, Cambridge, England.
1905		Bignold, Hugh Baron, Barrister-at-Law, Chambers, Wentworth Court, 64 Elizabeth-street.
1913		Bishop, Joseph Eldred, Journalist, Killarney-street, Mosman.
1905		Blakemore, George Henry, Australian Club, Macquarie-street.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Fremantle, West Australia.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.

Elected		
1898		Blunno, Michele, Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture. Sydney.
1907		Bogenrieder, Charles, Mining and Consulting Engineer, 'Scibile,' Little's Avenue, off Nicholson-street, Balmain.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1907		Boyd, Robert James, M.E., ASSOC. M. INST. C.E., 'Greenstead,' Park Road, Burwood,
1910		Bradley, Clement Henry Burton, M.B., CH.M., D.P.H., Demonstrator in Physiology in the University of Sydney.
1876		Brady, Andrew John, L.K. and Q.C.P. *Irel.*, L.R.C.S. *Irel.*, 175 Macquarie-street, Sydney.
1891		Brennand, Henry J. W., B.A., M.B., CH.M. *Syd.*, 'The Albany,' Macquarie-st., p.r. 'Wobun,' 310 Miller-st., North Sydney.
1902		Brereton, Victor Le Gay, Solicitor, 'Osgathorpe,' Gladesville.
1878		‡Brooks, Joseph, F.R A.S., F.R.G.S., 'Hope Bank,' Nelson-street, Woollahra.
1913		Browne, William Rowan, B.SC., Assistant Lecturer and Demonstrater in Geology in the University, Sydney.
1876		Brown, Henry Joseph, Solicitor, Newcastle,
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Kingston,' Merrylands.
1903		Bruck, Ludwig, Medical Publisher, 15 Castlereagh-street.
1898		‡Burfitt, W. Fitzmaurice, B.A., B.SC., M.B., CH.M. *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1890		Burne, Alfred, D.D.S., Buckland Chambers, 183 Liverpool-st.
1907		Burrows, Thomas Edward, M. INST. C.E., L.S., Metropolitan Engineer, Public Works Department; p.r. 'Balboa,' Fern-street, Randwick.
1880		Bush, Thomas James, M. INST. C.E., Australian Gas-light Company, 153 Kent-street.
1909		Calvert, Thomas Copley, ASSOC. M. INST. C.E., 'Maybank,' Manly.
1904	P 3	Cambage, Richard Hind, L.S., F.L.S., Chief Mining Surveyor; p.r. Park Road, Burwood. *Vice-President.*
1907		Campbell, Alfred W., M.D., CH.M. *Edin.*, 183 Macquarie-street.
1900		Canty, M., 'Rosemont,' 13 York-street, Wynyard Square.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd,, Edgecliffe.
1897	P 4	Cardew, John Haydon, M. INST. C.E., L.S., 75 Pitt-street.
1901		Card, George William, A.R S.M., F.G S., Curator and Mineralogist to the Geological Survey, Department of Mines, Sydney,
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F.F.A., *Scot.*, 4 Whaling Road, North Sydney. *Vice-President.*
1909		Carne, Joseph Edmund, F.G.S., Assistant Government Geologist, Department of Mines, Sydney.
1903		Carslaw, H. S., M.A., SC.D., Professor of Mathematics in the University of Sydney.
1913	P 2	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 1	Chapman, H. G., M.D., B.S., Assistant Professor of Physiology in the University of Sydney. *Hon. Treasurer.*

Elected		
1908		Chauleur, Paul, Officier de l'Instruction Publique, Conseiller du Commerce Extérieur de la France; Secrétaire-Trésorier de la Chambre de Commerce française, 2 Bond-st., G.P.O. Box 583, Sydney.
1913	P 2	Cheel, Edwin, Botanical Assistant, Botanic Gardens, Sydney.
1909	P 13	Cleland, John Burton, M.D., CH.M., Principal Assistant Microbiologist, Department of Public Health, 93 Macquarie-st.
1907		Cobham, Allan Blenman, 'Garthowen,' Myahgah Rd., Mosman.
1913		Cooke, William Ernest, Professor, M.A., F.R.A.S., Government Astronomer, The Observatory, Sydney.
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. INST. C.E., Water and Sewerage Board, North Sydney.
1904	P 2	Cooksey, Thomas, PH.D., D.SC. *Lond.*, F.I.C., Second Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman.
1913		Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. 55 Willoughby Road, North Sydney.
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.R.C.P. *Edin.*, 'Roseneath,' 8 Wallis-street, Woollahra.
1906		Colley, David John K., Superintendent, Royal Mint, Sydney.
1882		Cornwell, Samuel, J.P., Brunswick Road, Tyagarah.
1909	P 1	Cotton, Leo Arthur, B.A., B.SC., Assistant Lecturer and Demonstrator in Geology in the University of Sydney.
1892	P 1	Cowdery, George R., ASSOC. M. INST. C.E., Blashki Buildings, Hunter-st.; p,r. 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 16 College-street, Hyde Park.
1912		Curtis, Louis Albert, L.S., 'Redlands,' Union-street, Mosman.
1875		Dangar, Fred. H., c/o W. E. Deucher, 12 and 14 Loftus.street.
1890		Dare, Henry Harvey, M.E., M. INST. C.E., Public Works Department.
1876	P 3	Darley, Cecil West, M. INST. C.E., Australian Club, Sydney.
1910		Darnell-Smith, George Percy, B.SC., F.I.C., F.C.S., Department of Agriculture, Sydney.
1886	P 21	David, T. W. Edgeworth, C.M.G., B.A., D.SC., F.R.S., F.G.S., Professor of Geology and Physical Geography in the University of Sydney.
1909		Davidson, George Frederick, 223 Bridge Road, Glebe Point.
1892	P 1	Davis, Joseph, M. INST. C.E., Director-General, Public Works Department, Sydney.
1885	P 3	Deane, Henry, M.A., M. INST. C.E., F.L.S., F.R. MET. SOC., F.R.H.S., 'Campsie,' 14 Mercer Road, Malvern, Victoria.
1894		Dick, James Adam, B.A. *Syd.*, M.D., C.M., F.R.C.S. *Edin.*, 'Catfoss,' Belmore Road, Randwick.
1875	P 12	Dixon, W. A., F.I.C., F.C.S., 97 Pitt-street.
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
1876		Docker, His Honour Judge E. B., M.A., 'Mostyn,' Billyard Avenue, Elizabeth Bay.
1913		Dodd, Sydney, D.V.SC., F.R.C.V.S., Lecturer in Veterinary Pathology in the University, Sydney.
1913	P 2	Doherty, William M., Analyst, Department of Public Health, Sydney.

Elected		
1873	P 2	Du Faur, E., F.R.G.S., 'Flowton,' Turramurra.
1908	P 3	Dun, William S., Palæontologist, Department of Mines.
1908		Esdaile, Edward William, Optician, 54 Hunter-street.
1879	P 4	Etheridge, Robert, Junr., J.P., Curator, Australian Museum; p.r. 'Inglewood,' Colo Vale, N.S.W.
1877		‡Fairfax, Edward Ross, *S. M. Herald* Office, Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1868		Fairfax, Sir James R., Knt., *S. M. Herald* Office, Hunter-st.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, 5 Lyons Terrace.
1902		Faithfull, William Percy, Barrister-at-Law, Australian Club.
1912		Farnsworth, W. J., D.D.S. *Penn.*, Bannerman-st., Neutral Bay.
1910		Farrell, John, Assistant Teacher, Sydney Technical College; p.r. 8 Thompson-street, Darlinghurst.
1909	P 1	Fawsitt, Charles Edward, D.SC., PH.D., Professor of Chemistry in the University of Sydney.
1881		Fiaschi, Thos., M.D., M.CH. *Pisa*, 149 Macquarie-street.
1888		Fitzhardinge, His Honour Judge G. H., M.A., 'Red Hill,' Beecroft.
1900		‡Flashman, James Froude, B.A., B.SC., M.D., CH.M., Jersey Road, Burwood.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'Wyoming,' Macquarie-street.
1905		Foy, Mark, 'Eumemering,' Bellevue Hill, Woollahra.
1904		Fraser, James, M. INST. C.E., Engineer-in-Chief for Existing Lines, Bridge-street; p.r. 'Arnprior,' Neutral Bay.
1907		Freeman, William, 'Clodagh,' Beresford Road, Rose Bay.
1899		French, J. Russell, General Manager, Bank of New South Wales, George-street.
1881		Furber, T. F., F.R.A.S., Lands Department.
1876		George, W. R., 'Warialda,' Neutral Bay.
1906		Gosche, W. A. Hamilton, Electrical Engineer, 24½ Pitt-street, Sydney.
1897		Gould, Senator The Hon. Sir Albert John, K.C.M.G., 'Eynesbury,' Edgecliffe.
1907		Green, W. J., Chairman, Hetton Coal Co., Athenæum Club.
1899		Greig-Smith, R., D.SC. *Edin.*, M.SC. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay.
1912		Grieve, Robert Henry, B.A., 'Langtoft,' Llandaff-st., Waverley.
1912		Griffiths, F. Guy, B.A., M.D., CH.M., 135 Macquarie-st., Sydney.
1899	P 2	Gummow, Frank M., M.C.E., Corner of Bond and Pitt-streets.
1891	P 16	Guthrie, Frederick B., F.I.C., F.C.S., Chemist, Department of Agriculture, 137 George-street, Sydney. *Vice-President.*
1880	P 4	Halligan, Gerald H., F.G.S., 'Riversleigh,' Hunter's Hill.
1912		Hallmann, E. F., B.SC., Biology Department, The University, Sydney.

Elected		
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1909		Hammond, Walter L., Science Master, Hurlstone Agricultural Continuation School, Hurlstone Avenue, Summer Hill.
1912		Hamilton, A. G., Lecturer on Nature Study, Teachers' College, Blackfriars.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; Government Analyst, Health Department, Macquarie-street, North.
1912		Hare, A. J., Under Secretary for Lands, 'Booloorool,' Monte Christo-street, Woolwich.
1905	P 1	Harker, George, D.SC., Assistant Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1887	P 23	‡Hargrave, Lawrence, Wunulla Road, Woollahra Point.
1913		Harper, Leslie F., F.G.S., Geological Surveyor; Department of Mines, Sydney.
1884	P 1	Haswell, William Aitcheson, M.A., D.SC., F.R.S., Professor of Zoology and Comparative Anatomy in the University of Sydney; p.r. 'Mimihau,' Woollahra Point.
1900		Hawkins, W. E., Solicitor, 88 Pitt-street.
1891	P 1	Hedley, Charles, F.L.S., Assistant Curator, Australian Museum, Sydney.
1899		Henderson, J., F.R.E.S., Manager, City Bank of Sydney, Pitt-st.
1884	P 1	Henson, Joshua B., ASSOC. M. INST. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1905		Hill, John Whitmore, Architect, 'Willamere,' May's Hill, Parramatta.
1876	P 2	Hirst, George D., F.R.A.S., c/o Messrs. Tucker & Co., 215 Clarence-street.
1892		Hodgson, Charles George, 157 Macquarie-street.
1901		Holt, Thomas S., 'Amalfia,' Appian Way, Burwood.
1905		Hooper, George, Assistant Superintendent, Sydney Technical College; p.r. 'Banksome,' Henson-street, Summer Hill.
1891	P 2	Houghton, Thos. Harry, M. INST. C.E., M. I. MECH. E., 63 Pitt-st.
1906		Howle, Walter Cresswell, L.S.A. *Lond.*, 'Malcolm House,' Bega.
1913		Hudson, G. J., Manufacturing Chemist. 'Gudvangen,' Arden-street, Coogee.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines.
1904		Jenkins, R. J. H., 'Ettalong,' Roslyn Gardens, Rushcutters' Bay.
1905	P 8	Jensen, Harold Ingemann, D.SC., Government Geologist, Darwin, Northern Territory.
1909	P 13	Johnston, Thomas Harvey, M.A., D.SC., F.L.S., Biology Department, The University, Brisbane.
1867		Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 'Llandilo, Boulevarde, Strathfield.
1911		Julius, George A., B.SC., M.E., Norwich Chambers, Hunter-st.
1907		Kaleski, Robert, Agricultural Expert, Holdsworthy, Liverpool.
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.
1873	P 3	Keele, Thomas William, M. INST. C.E., Commissioner, Sydney Harbour Trust, Circular Quay; p.r. Llandaff-st., Waverley.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, Pitt-street.

Elected		
1901		Kidd, Hector, M. INST. C.E., M. I. MECH. E., 'Craig Lea,' 15 Mansfield-street, Glebe Point.
1896		King, Kelso, 120 Pitt-street.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 'Roseville,' Edward-street, Bondi.
1881	P 22	Knibbs, G. H., C.M.G., F.S.S., F.R.A.S., Member Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; Commonwealth Statistician, Melbourne.
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1913		Kuntzen, Harold Eric, Manufacturing Chemist, Australian Glue and Gelatine Works, Alexandria.
1911	P 2	Laseron, Charles Francis, Technological Museum.
1913		Lawson, A. Anstruther, D.SC., F.R.S.E., Professor of Botany in the University of Sydney.
1906		Lee, Alfred, 'Glen Roona,' Penkivil-street, Bondi.
1909		Leverrier, Frank, B.A., B.SC., K.C., 182 Phillip-street.
1883		Lingen, J. T., M.A. *Cantab.*, Selborne Chambers, Phillip-street.
1906		Loney, Charles Augustus Luxton, M. AM. SOC. REFR. E., Equitable Building, George-street.
1911		Longmuir, G. F., B.A., Science Master, Technical College, Bathurst.
1912		Lovell, Henry Tasman, M.A., PH.D., 'Tane,' Hodson Avenue, Cremorne.
1884		MacCormick, Sir Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street, North.
1887		MacCulloch, Stanhope H., M.B., CH.M, *Edin.*, 24 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co, Ld., 2 Spring-street.
1903		McDonald, Robert, J.P., Pastoral Chambers, O'Connell-street; 'Wairoa.' Holt-street, Double Bay,
1891		McDouall, Herbert Chrichton, M.R.C.S. *Eng.*, L.R.C.S. *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1906		McIntosh, Arthur Marshall, Dentist, 157 Macquarie-street, Sydney; Hill-street, Roseville.
1891	P 2	McKay, R. T., ASSOC. M. INST. C.E., Geelong Waterworks and Sewerage Trusts Office, Geelong, Victoria.
1876		Mackellar, The Hon. Sir Charles Kinnaird, M.L.C., M.B., C.M. *Glas.*, Equitable Building, George-street.
1904		McKenzie, Robert, Sanitary Inspector, (Water and Sewerage Board), 'Stonehaven Cottage,' Bronte Road, Waverley.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. INST. C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.
1912	P 1	MacKinnon, Ewen, B.SC., Assistant Microbiologist, Department of Public Health, Macquarie-street.
1903		McLaughlin, John, Solicitor, Union Bank Chambers, Hunter-st.
1876		MacLaurin, The Hon. Sir Henry Normand, M.L.C., M.A., M.D., L.R.C.S. *Edin.*, LL.D. *St. Andrews*, 155 Macquarie-street.
1901	P 1	McMaster, Colin J., Chief Commissioner of Western Lands; p.r. Wyuna Road, Woollahra Point.
1894		McMillan, Sir William, K.C.M.G., 'Althorne,' 281 Edgecliffe Road, Woollahra.
1899		MacTaggart, J. N. C., M.E. *Syd.*, ASSOC. M. INST. C.E., Water and Sewerage Board District Office, Lyons Road, Drummoyne.

Elected		
1909		Madsen, John Percival Vissing, D.SC., B.E., P. N. Russell Lecturer in Electrical Engineering in the University of Sydney.
1883	P 25	Maiden, J. Henry, J.P., F.L.S., Hon. Fellow Roy. Soc. S.A.; Hon. Memb. Nat. Hist. Soc., W.A.; Netherlands Soc. for Promotion of Industry; Philadelphia College Pharm.; Southern Californian Academy of Sciences; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin.; Soc Nat. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc. Tas.; Roy. Soc. Queensl.; Inst. Nat. Genévois; Hon. Vice-Pres. of the Forestry Society of California; Diplômé of the Société Nationale d'Acclimatation de France; Government Botanist and Director, Botanic Gardens, Sydney. *Hon. Secretary.*
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1897		Marden, John, M.A., LL.D., Principal, Presbyterian Ladies' College, Sydney.
1908		Marshall, Frank, B.D.S. *Syd.*, 141 Elizabeth-street.
1875	P 27	Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d' Anthrop. de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor, Mem. Anthrop. Soc. Vienna; Cor. Mem. Roy. Geog. Soc. Aust. Q'sland; Local Correspondent Roy. Anthrop. Inst., Lond.; 'Carcuron,' Hassall-st., Parramatta.
1903		Meggitt, Loxley, Manager Co-operative Wholesale Society, Alexandria.
1912		Meldrum, Henry John, p.r. 'Craig Roy,' Sydney Rd., Manly.
1905		Miller, James Edward, Broken Hill, New South Wales.
1889	P 8	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines, p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Union Club, Sydney.
1877		‡Mullens, Josiah, F.R.G.S., 'Tenilba,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 95 Macleay-street, Potts Point.
1876		Myles, Charles Henry, 'Dingadee,' Everton Rd., Strathfield.
1893	P 3	Nangle, James, F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; p.r. 'St. Elmo,' Tupper-street, Marrickville.
1891		‡Noble, Edward George, 8 Louisa Road, Balmain.
1893		Noyes, Edward, ASSOC. M. INST. C.E., ASSOC. I. MECH. E., c/o Messrs. Noyes Bros., 115 Clarence-street, Sydney.
1903		‡Old, Richard, Solicitor, 'Waverton,' Bay Road, North Sydney.
1913		Ollé, A. D., 'Kareema,' Charlotte-street, Ashfield.
1896		Onslow, Col. James William Macarthur, 'Gilbulla,' Menangle.
1875		O'Reilly, W. W. J., M.D., CH.M. Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 171 Liverpool-street, Hyde Park.
1891		Osborn, A. F., ASSOC. M. INST. C.E., Water Supply Branch, Sydney, 'Uplands,' Meadow Bank, N.S.W.

Elected		
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 183 Liverpool-street, Hyde Park.
1906		Pawley, Charles Lewis, Dentist, 137 Regent-street.
1901		Peake, Algernon, ASSOC. M. INST. C.E., 25 Prospect Rd., Ashfield.
1899		Pearse, W., Union Club; p.r. 'Plashett,' Jerry's Plains, viâ Singleton.
1877		Pedley, Perceval R., New South Wales Club.
1899		Petersen, T. Tyndall, Member of Sydney Institute of Public Accountants, 4 O'Connell-street.
1909	P 1	Pigot, Rev. Edward F., S.J., B.A., M.B. *Dub.*, St. Ignatius' College, Riverview.
1879	P 7	Pittman, Edward F., ASSOC. R. S. M., L.S., Under Secretary and Government Geologist, Department of Mines.
1896		Plummer, John, 'Northwood,' Lane Cove River; Box 413 G.P.O.
1881		Poate, Frederick, Surveyor-General, Lands Department, Sydney.
1879		Pockley, Thomas F. G., Union Club, Sydney.
1887	P 8	Pollock, J. A., D.SC., Corr. Memb. Roy, Soc. Tasmania; Roy. Soc. Queensland; Professor of Physics in the University of Sydney. *Hon. Secretary.*
1896		Pope, Roland James, B.A., *Syd.*, M.D., C.M., F.R.C.S., *Edin.*, 183 Macquarie-street.
1910		Potts, Henry William, F.L.S., F.C.S., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1893		Purser, Cecil, B.A., M.B., CH.M. *Syd.*, 139 Macquarie-street.
1901	P 1	Purvis, J. G. S., Water and Sewerage Board, 341 Pitt-street.
1908		Pye, Walter George, M.A., B.SC., *S. M. Herald* Office, Pitt and Hunter-streets, Sydney.
1876	P 1	Quaife, F. H., M.A., M.D., M.S., 'Yirrimbirri,' Stanhope Road, Killara. *Vice-President.*
1912		Radcliff, Sidney, Chemist, Radium Hill Works, Woolwich.
1890	P 1	Rae, J. L. C., 'Lisgar,' King-street, Newcastle.
1865	P 1	‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S E., F.L.S., Queensborough Road, Croydon Park.
1906		Redman, Frederick G., P. and O. Office, Pitt-street.
1909		Rhodes, Thomas, Civil Engineer, Room 14, Public Works Department, Sydney.
1902		Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1906		Richardson, H. G. V., 32 Moore-street.
1913		Robinson, Robert, D.SC., Professor of Organic Chemistry in the University of Sydney.
1913		Roseby, Thomas, M.A,, LL.D. *Syd.*, F.R.A.S. *Lond.*, 'Tintern,' Mosman.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 151 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1904	P 3	Ross, William J. Clunies, B.SC. *Lond. and Syd.*, F.G.S., Lecturer in Chemistry, Technical College, Sydney.
1882		Rothe, W. H., Colonial Sugar Co., O'Connell-street, and Union Club.

Elected		
1897		Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, ASSOC. M. INST. C.E., City Bank Chambers, Pitt-street, Sydney.
1913		Scammell, W. J., Manufacturing Chemist, Mem. Phar. Soc. *Grt. Brit.*, 18 Middle Head Road, Mosman.
1905		Scheidel, August, PH.D., Managing Director, Commonwealth Portland Cement Co., Sydney; Union Club.
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., Assistant Professor of Chemistry in the University of Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1904	P 1	Sellors, R. P., B.A. *Syd.*, 'Mayfield,' Wentworthville.
1908		Sendey, Henry Franklin, Manager of the Union Bank of Australia Ld., Sydney; Union Club; p.r. 'The Hermitage,' Vaucluse Road, Rose Bay.
1883	P 4	Shellshear, Walter, M. INST. C.E., Inspecting Engineer, Existing Lines Office, Bridge-street.
1900		Simpson, R. C., Technical College, Sydney.
1910		Simpson, William Walker, Leichhardt-street, Waverley.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. 'Broomage,' Kangaroo-street, Manly.
1893		Sinclair, Russell, M. I. MECH. E., Vickery's Chambers, 82 Pitt-st.
1891	P 3	Smail, J. M., M. INST. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1912		Smart, Bertram James, B.SC., Public Works Office, Lithgow.
1893	P 44	Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney. *President.*
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1892	P 1	Statham, Edwyn Joseph, ASSOC. M. INST. C.E., Cumberland Heights, Parramatta.
1913		Stewart, Alex. Hay, B.E., Metallurgist, Technical College, Sydney.
1900		Stewart, J. Douglas, B.V.SC., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; 'Berelle,' Homebush Road, Strathfield.
1903		Stoddart, Rev. A. G., The Rectory, Manly.
1909		Stokes, Edward Sutherland, M.A. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1883	P 4	Stuart, T. P. Anderson, M.D., CH.M., LL.D. *Edin.*, D.SC., Professor of Physiology in the University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay.
1913		Stuart, James Henry Cohen, Manager in Sydney of the Royal Packet, S. N. Co., 56 Pitt-street, Sydney.
1901	P 6	Süssmilch, C. A., F.G.S., Technical College, Newcastle.
1912		Swain, E. H. F., District Forester, Narrabri.

Elected		
1906		Taylor, The Hon. Sir Allen, M.L.C., 'The Albany,' Macquarie-st.
1906		Taylor, Horace, Registrar, Dental Board, 7 Richmond Terrace, Domain,
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1893		‡Taylor, James, B.SC., A.R.S.M., 'Betys,' Montague Road, Neutral Bay.
1899		Teece, R., F.I.A., F.F.A., General Manager and Actuary, A.M.P. Society, 87 Pitt-street.
1861	P 19	Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1878		Thomas, F. J., 'Lovat,' Nelson-street, Woollahra.
1879		Thomson, The Hon. Dugald, Carrabella-st., North Sydney.
1885	P 2	Thompson, John Ashburton, M.D. *Brux.*, D.P.H. *Cantab.*, M.R.C.S. *Eng.*, Health Department, Macquarie-street.
1896		Thompson, Major A. J. Onslow, Camden Park, Menangle.
1913		Thompson, Joseph, M.A., LL.B., Solicitor, Vickery's Chambers, 82 Pitt-street, Sydney.
1892		Thow, William, M. INST. C.E., M. I. MECH. E., 'Inglewood,' Lane Cove Road, Wahroonga.
1913		Tietkens, William Harry, 'Upna,' Eastwood.
1879		Trebeck, P. C., F. R. MET. SOC., 12 O'Connell-street.
1900		Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st.
1913		Ullrich, Richard Emil, Accountant, 43 Bond-street, Mosman.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'BayView House,' Tempe.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S Guild; Challis House, Martin Place.
1892		Vickery, George B., 78 Pitt-street.
1903	P 3	Vonwiller, Oscar U., B.SC., Assistant Professor of Physics in the University of Sydney.
1907		Waley, F. G., ASSOC. M. INST. C.E., Royal Insurance Building, Pitt-street.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, The Hon. J. T., F.R.C.I., Fellow of Institute of Bankers *Eng.*, 'Wallaroy,' Edgecliffe Road, Woollahra.
1910		Walker, Charles, Metallurgical Chemist, 80 Bathurst-street, p.r. 'Kuranda,' Waverley-street, Waverley.
1910		Walker, Harold Hutchison, Major, C.M.F., 'Vermont,' Belmore Road, Randwick.
1910	P 1	Walkom, Arthur Bache, B.SC., The University of Queensland, Brisbane.
1901		Walkom, A. J., A.M.I.E.E., Electrical Branch, G.P.O., Sydney.
1891	P 2	Walsh, Henry Deane, B.A.I. *Dub.*, M. INST. C.E., Commissioner and Engineer-in-Chief, Harbour Trust, Circular Quay.

Elected		
1903		Walsh, Fred., J.P., Capt. C.M.F., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; For. Memb. Soc. German Patent Agents, Berlin; Regd. Patent Attorn. Comm. of Aust.; Memb Patent Attorney Exam. Board Aust.; George and Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Sydney E.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1913		Wardlaw, Hy. Sloane Halcro, B.SC. *Syd.*, 87 Macpherson-street, Waverley.
1883	P 17	Warren, W. H., LL.D., WH. SC., M. INST. C.E., M. AM. SOC. C.E., Member of Council of the International Assoc. for Testing Materials, Professor of Engineering in the University of Sydney.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman, Atorney General's Department, Macquarie-st.
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville.
1910		Watson, James Frederick, M.B., CH. M., Australian Club, Sydney.
1910		Watt, Francis Langston, F.I.C., A.R.C.S., 10 Northcote Chambers, off 16½ Pitt-street, City.
1911		Watt, R. D., M A., B.SC., Professor of Agriculture in the University of Sydney.
1910	P 1	Wearne, Richard Arthur, B.A., Principal, Technical College, Ipswich, Queensland.
1897		Webb, Frederick William, C.M.G., J.P., 'Livadia,' Manly.
1892		Webster, James Philip, ASSOC. M. INST. C.E., L.S., *New Zealand*, Town Hall, Sydney.
1907		Weedon, Stephen Henry, C.E., 'Kurrowah,' Alexandra-street, Hunter's Hill.
1907		Welch, William, F.R.G.S., 'Roto-iti,' Boyle-street, Mosman.
1881		‡Wesley, W. H., London.
1892		White. Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D. *Dub.*
1909		White, Charles Josiah, B.SC., Science Lecturer, Sydney Training College; p.r. 'Byrntryird,' 49 Prospect Rd Summer H.
1907		Wiley, William, 'Kenyon,' Kurraba Point, Neutral Bay.
1876		Williams, Percy Edward, 'St. Vigeans,' Dundas.
1908	P 1	Willis, Charles Savill, M.B., CH.M. *Syd.*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H., *Lond.*, Department of Public Instruction, Bridge-street.
1901		Willmot, Thomas, J.P., Toongabbie.
1890		Wilson, James T., M.B., CH.M. *Edin*, F.R.S., Professor of Anatomy in the University of Sydney.
1907		Wilson, W. C., Public Works Department, Sydney.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1909		Woodhouse, William John, M.A., Professor of Greek in the University of Sydney.
1906	P 6	Woolnough, Walter George, D.SC., F.G.S., Professor of Geology in the University of Western Australia, Perth.
1909		Yeomans, Richard John, Solicitor, 14 Castlereagh-street.

Elected		
		HONORARY MEMBERS.
		Limited to Twenty.
		M.—Recipients of the Clarke Medal.
1900		Crookes, Sir William, Kt., O.M., LL.D., D.SC., P.R.S., 7 Kensington Park Gardens, London W.
1905		Fischer, Emil, Professor of Chemistry in the University of Berlin.
1911		Hemsley, W. Botting, LL.D., F.R.S., Formerly Keeper of the Herbarium, Royal Gardens, Kew, 24 Southfield Gardens, Strawberry Hill, Middlesex.
1901		Judd, J.W., C.B., LL.D., F.R.S., F.G.S., Formerly Professor of Geology, Royal College of Science, London; 30 Cumberland Road, Kew, England.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. ENG., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1908	P 57	*Liversidge, Archibald, M.A., LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney, 'Fieldhead,' George Road, Coombe Warren, Kingston, Surrey.
1912		Martin, C. J., D SC., F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London.
1905		Oliver, Daniel, LL.D., F.R.S., Emeritus Professor of Botany in University College, London.
1894		Spencer, W. Baldwin, C.M.G., M.A., D.SC., F.R.S., Professor of Biology in the University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL.D., SC.D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1908		Turner, Sir William, K.C.B., M.B., D.C.L., LL.D., SC.D., F.R.C.S. *Edin.*, F.R.S., Principal and Emeritus Professor of the University of Edinburgh, 6 Eton Terrace, Edinburgh, Scotland.

* Retains the rights of ordinary membership. Elected 1872.

OBITUARY 1913.

Honorary Member.

1895	Wallace, Alfred Russel.

Ordinary Members.

1884	Jones, Llewellyn Charles Russell.
1895	Adams, J. H. M.
1910	Estens, John Locke.
1859	Goodlet, J. H.
1896	Hinder, Henry Critchley.
1879	Whitfeld, Lewis.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

THE REVD. W. B. CLARKE, M.A., F.R.S., F.G.S., etc.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

Awarded

1878 *Professor Sir Richard Owen, K.C.B., F.R.S.

1879 *George Bentham, C.M.G., F.R.S.

1880 *Professor Thos. Huxley, F.R.S.

1881 *Professor F. M'Coy, F.R.S., F.G.S.

1882 *Professor James Dwight Dana, LL.D.

1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S.

1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.

1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

1886 *Professor L. G. De Koninck, M.D., University of Liège.

1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.

1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.

1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.

1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.

1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., SC.D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.

1893 *Professor Ralph Tate, F.L.S., F.G.S.

1895 Robert Logan Jack, F.G.S., F.R.G.S., late Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Curator of the Australian Museum, Sydney

1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.

1900 Sir John Murray, K.C.B., LL.D., SC.D., F.R.S., Challenger Lodge, Wardie, Edinburgh.

1901 *Edward John Eyre.

1902 F. Manson Bailey, F.L.S., Colonial Botanist of Queensland, Brisbane.

1903 *Alfred William Howitt, D.SC. F.G.S.

1907 Walter Howchin, F.G.S., University of Adelaide.

1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.

1912 Twelvetrees, W. H., F.G.S., Government Geologist. Launceston, Tasmania.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney for paper entitled 'The Tin deposits of New South Wales.'

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, D.SC., M.B., F.R.S., Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

ISSUED SEPTEMBER 19th, 1913.

Vol. XLVII. **Part I.**

JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1913

PART I., (pp. 1-112).

CONTAINING PAPERS READ IN

MAY to AUGUST (*in part*).

WITH FOUR PLATES.

(Plates i, ii, iii, iv.)

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH, SYDNEY.
LONDON AGENTS:
GEORGE ROBERTSON & Co., PROPRIETARY LIMITED,
17 WARWICK SQUARE, PATERNOSTER ROW, LONDON, E.C.

1913.

F. WHITE Typ., 344 Kent Street Sydney.

PRESIDENTIAL ADDRESS.

By R. H. CAMBAGE, L.S., F.L.S.

With Plate I.

[*Delivered to the Royal Society of N. S. Wales, May 7, 1913.*]

HAVING been accorded the honour of addressing you as your President, I purpose on this, the ninety-second anniversary of the existence of our Society, to first refer to a few matters of general interest, and then to offer some observations on the development and distribution of the genus Eucalyptus.

Necrology.

I have first to refer to five of our late members who have been taken from us by the hand of death.

WILLIAM ROSSBACH, Assoc. M. Inst. C.E., who joined this Society in 1892, was born at Woollahra on 10th August, 1862, and died at Waverley on 21st November, 1911. He entered the Public Service as an engineering cadet on 4th July, 1877, and subsequently occupied the positions of Chief Draftsman and Assistant Engineer in the Harbours and Rivers Branch of the Public Works Department. In the latter position he exercised control over the whole of the works and often acted as head of the branch. He was employed under the late Mr. E. O. Moriarty, Engineer-in-Chief for Harbours and Rivers, and the subsequent occupiers of this office, viz.:—Messrs. C. W. Darley, R. R. P. Hickson, T. W. Keele, L. A. B. Wade, and E. M. de Burgh, in the design of such works as the Sydney, Hunter River District, and various Country Towns Water Supplies, the Wharfage and Harbour Improvement Works of Sydney, Newcastle, Port Kembla, and Coastal Rivers. He took a prominent part in the design of the Cataract Dam, and it was on his investigations that Mr. Keele successfully pressed for its

construction to the height designed, a course of action which the overflowing of the dam has since proved was correct. The investigation of the whole of the Harbour proposals in connection with the Royal Commission on Decentralisation was made by Mr. Rossbach. He made a special study of his particular branch of the profession and was recognised as one of the most capable Harbour Engineers in the State. In 1891 he was elected an Associate Member of the Institute of Civil Engineers.

BEN. M. OSBORNE, J.P., was a member of the Royal Society for twenty-nine years, having joined in 1883. He was born at Marshall Mount, Illawarra, on the 11th August, 1837, and died at Hopewood, Bowral, on the 15th January, 1912. His life was chiefly devoted to pastoral pursuits, and amongst his various properties were the famous Redbank and Jugiong Estates on the Murrumbidgee. He was possessed of the highest progressive ideas, and expended large sums in improving his stock by importations, which resulted in his horses, cattle and sheep ranking amongst the finest in the State.

LLEWELLYN CHARLES RUSSELL JONES, a well known Sydney Solicitor, who joined this Society in 1884, was born in Sydney in November, 1856. He died at Southport, England, on 13th May, 1912, and was buried at Waverley near Sydney. He greatly interested himself in municipal and political affairs and was elected an alderman of Petersham in 1886, which position he held continuously up to the time of his death, being Mayor for several successive years. He represented Petersham in Parliament from 1894 to 1898. He occupied a seat on the Board of Directors of several companies, and was also a Director of the Sydney Hospital and of the New South Wales Deaf and Dumb Institution, as well as President of the Cymrodorean Society. A deep interest was taken by him in Masonic

matters, and he was at one time Master of Lodge Ionic and subsequently a member of the Grand Lodge of New South Wales.

John H. Adams joined this Society in 1895, and died at Waverley on 23rd March, 1913, aged 64. He entered the Works Department in 1876, and was appointed Road Superintendent to the Walgett District in 1882. He was afterwards transferred in the same capacity, first to Orange, and then to Mudgee, and finally left the Department in 1895. Many of the excellent roads in the Districts referred to testify to Mr. Adams' energy and engineering ability. He was a popular officer who was entirely devoted to his work, and could be found engaged upon it early and late. The valuable work carried out by the officers of the Road Engineering Staff passes by without much notice, as these officers are not prominently before the public, but their work is of inestimable value in developing the resources of the country. Mr. Adams was a man of genial disposition, and being an excellent whip, one of his favourite diversions was driving a good team of horses.

John Locke Estens was born at Bath on the 20th December, 1859, and joined this Society in 1910. His family can be traced back to John Locke the famous philosopher, who lived from 1632 to 1704, and also to John Locke who was Sheriff of London in 1460. When a boy, he was a chorister at St. Stephen's Church, Lansdown. He came to Australia in 1883, and entered into business in connection with the sale of musical instruments. He inherited musical tastes, and twenty years ago was a soloist at St. James Church, King Street, Sydney. He also found time to devote some portion of his leisure to literary pursuits and produced a work entitled "Paraclete and Mahdi," a copy of which he presented to this Society. His death took place at Maldon, New South Wales, on the 26th April, 1913.

General Scientific Matters.

Australasian Association for the Advancement of Science.—A most successful meeting of the above Society was held in Melbourne last January, at which the papers presented were numerous, varied and full of interest. Several profitable excursions were made on different scientific quests, and the whole meeting demonstrated in a marked degree, the great value of these gatherings from the point of view that scientists from all parts of Australasia are enabled to meet in an informal way at the various functions, to the mutual advantage of all concerned.

British Association for the Advancement of Science—Australian Meeting.—During the coming year the arrangements should be advanced towards completion, for the holding in August 1914 of what will be the most important scientific gathering ever assembled in Australia. It is well to be reminded of this in order that we may use our utmost endeavours to make this meeting an unqualified success.

Under the general supervision of Professor David, who is Chairman of the New South Wales Executive Committee, and who was requested by the Prime Minister to undertake local arrangements, various committees are already at work preparing for the reception of the coming scientists, and amongst other matters which the Science Committee have in hand is that of the preparation of a New South Wales handbook of about 500 pages, dealing with the social and natural science of the State, and which is intended for distribution amongst members of the British Association. A Federal Council has been formed, with the Prime Minister as Chairman, and is composed of delegates from all the States.

It has been arranged by the Federal Council, with the consent of the Prime Minister, that a Commonwealth handbook for Australia shall be prepared by the Federal Statis-

tician, while each State will be expected to provide its own handbook. The Commonwealth Government, at the instance of a sympathetic Prime Minister, and the general approval of Parliament, has undertaken to provide £15,000 towards the expense of bringing out at least 150 leading scientists, and is also providing the funds necessary to send an organising secretary to England to confer with the British Association in regard to all arrangements. Provision is also being made by the Commonwealth Government to have reports of the various meetings specially prepared and despatched to the London Press in order that the fullest benefit may be secured from the visit. Such enlightened and generous action must be regarded as a graceful tribute to science, but it is not too much to say, that the advantage of having amongst us, in a semi-official capacity, an assemblage composed of some of Britain's brightest scientific intellects, who will be able to make a first-hand acquaintance with the wonderful resources of this magnificent country, must ultimately be a tenfold advantage to Australia.

It has been decided that the main party will visit Adelaide, Melbourne, and Sydney, and an endeavour is being made to arrange for some of the Association's members to visit all the remaining States of Australia and the Dominion of New Zealand.

The British Association has been notified that it is the desire of the Federal Council, that about twenty invited Dominion and Foreign guests should be included in the official party if such can be arranged, and while the selection of such guests and the ultimate decision as to their number must be left to the British Association, suggestions are being made as to the scientists who would be specially welcome. The local Science Committee has already attended to the matter for this State, and submitted a list

containing over forty names, from which, together with those from the other States, a final selection may be made.

Government Astronomer and Chair of Astronomy.—Since the death in 1908, of Mr. H. A. Lenehan, a former President of this Society, New South Wales has been without a Government Astronomer. The filling of this position during the past year by the appointment of Professor Cooke is a matter for congratulation by all scientists. Of equal satisfaction is the fact, that a Chair of Astronomy has been established at the Sydney University, in charge of which Professor Cooke has also been placed. Astronomy ranks as one of the oldest and most exalted of the sciences, and it is gratifying to see that our State, is taking its place with other countries in the study and the teaching of this noble science.

Chair of Botany.—In the establishment of a Chair of Botany, which has been placed under the direction of Professor Lawson, a distinctly progressive step has been made. Both as a scientific and as a commercial asset, the flora of New South Wales is most valuable, and quite apart from the advancement to science, culture and refinement, which a love for the study of our native flora must promote, there are also the many economic products amongst its timbers, barks, essential oils, etc., that require to be further investigated and studied before all their valuable properties can be known and applied to their fullest advantage. An advance, therefore, such as this, in the scope and facilities for training Australian botanists, merits our best appreciation.

Chair of Organic Chemistry.—Intertwined to a large extent with an extended study of botany is that of organic chemistry, and as time goes on, the phyto-chemist and vegetable physiologist will render more and more assist-

ance in the elucidation of plant mysteries. It is those who have given attention to, or who have been in some way associated with the work of the organic chemist as applied to our most interesting Australian flora, who can best appreciate the wonderful properties and scientific interest as well as economic value of our native plant-life: and now that a Chair of Organic Chemistry has been established at our University, under the charge of Professor Robinson, we may hopefully look forward to a further extension of our knowledge in this direction, as the possibilties of the profitable utilisation of the wonderful vegetation of Australia seem to be unlimited.

Chair of Economics.—A Chair of Economics has also been established, with Professor Irvine in control, and this step may be regarded as further evidence of progress.

The establishment of four new Professorial Chairs at the Sydney University is a matter for sincere congratulation by all scientific people. It should be impossible for any thinking person to watch the rapid development of our splendid country, with its vast resources and increasing wealth, without at the same time trying to make some comparison between its great educational and scientific institutions and those of other countries. The contemplation of our possibilities in the above connection, should fire Australians with an ambition to take a prominent place in the world of science, and with our mental, physical and resourceful equipment there should be no reason why we should not succeed in doing so. We look to our Universities to train young scientists for research work, and in our aspiration to advance science, we hail with the utmost satisfaction any enlargement of the scope of the University which tends to furnish the State with an increased number of specially trained scientists.

Antarctica.

During our recess the world has been shocked and grieved beyond measure by learning of the tragic and heroic deaths of no less than seven Antarctic explorers. First came the tidings that the whole of the Polar party had perished after having achieved the distinction of reaching the South Pole. The ill-fated band who added their names to the roll of fame are:—

Captain R. F. SCOTT, Leader of the Expedition.
Dr. EDWARD A. WILSON, Chief of the Scientific Staff.
Captain L. E. G. OATES, Inniskilling Dragoons.
Lieutenant HENRY R. BOWERS, Royal Indian Marine.
Petty Officer EDGAR EVANS.

Immediately on receiving notification of this overwhelming disaster, I despatched a cable on behalf of the Society, to the President of the Royal Geographical Society of London, expressing profound regret at the loss of the gallant party. We have since all become familiar with the circumstances surrounding the end of this heroic five and their final services to science, and it seems no exaggeration to say that a feeling of veneration for such fortitude, such heroism, and such devotion to duty as they displayed, will live in the hearts of the British race for centuries to come.

Before we had recovered from the shock of this thrilling event, there came the further tidings of disaster to Dr. Mawson's Australasian Expedition, and we learnt of the sad loss of Lieutenant B. E. S. Ninnis and Dr. Xavier Mertz which occurred under such tragic circumstances. Anticipating your wishes I sent a wireless message on behalf of this Society to Dr. Mawson, deploring the sad loss of his brave comrades and expressing our sympathy.

It is impossible to read of the subsequent perilous voyage of portion of Mawson's party, and the shipping of the western party which was under Mr. Frank Wild, without

realising the important service in averting further possible disaster, which was rendered by the sound judgment and skilful seamanship of Captain John King Davis.

Scientific Work in Antarctica.—First, in regard to the scientific results obtained by the late Captain R. F. Scott, British Antarctic Expedition, a good summary has already been published in "Nature," February 20, 1913. In reference to geological results, Mr. T. Griffith Taylor, the geologist in charge, with Mr. Frank Debenham of Sydney University, made the important discovery of the remains—apparently bony plates—of what was probably a large fossil fish in the black carbonaceous shales of the Beacon Sandstone formation. They also discovered coal of fair quality at Granite Harbour, 100 miles to the north-west of their winter quarters at Cape Evans near Mount Erebus. Amongst the geological specimens (of which a weight of 35 ℔s was carried back all the way from the head of the Beardmore glacier to the spot where Captain Scott and his comrades eventually perished) are several well-preserved remains of fossil leaves also taken from these same coal measures which belong to the horizon of the Beacon Sandstone. Mr. Debenham, the only geologist who has as yet seen these specimens, considers that the leaves show a netted venation and probably belong either to *Glossopteris*, *Gangamopteris*, or *Sagenopteris*. In either case these leaves would suggest that the Beacon Sandstone is of Gondwana age, that is from Permo-carboniferous to Upper Trias. At the same time it should be mentioned that Professor Lawson of Sydney University, thinks it quite possible that some of the fossil wood obtained by Mr. R. E. Priestley from near Mount Nansen is of newer age, being probably angiospermous. At present, as far as is known, the oldest angiosperms do not descend below the Cretaceous horizon.

Taylor and Debenham ascertained that the ice of a large outlet glacier draining the inland plateau moved in summer at the rate of 80 feet per month. This is a lower rate than that already ascertained for the movement of the Ross Barrier as a whole, the rate of movement of the latter being about, on the average, 120 feet per month.

Mr. R. E. Priestley, the geologist in charge with Lieutenant Campbell's party, in addition to discovering the important specimens of fossil wood above referred to, has accumulated a large amount of very valuable information on the local ice barrier near Mount Nansen which was formerly united to the Great Ice Barrier (or Ross Barrier). He also led an expedition which succeeded in successfully ascending Mount Erebus and was able to gain important information, additional to that obtained by the members of the Shackleton expedition, as to the existence of the most powerful geyser known in the world to the north of Mount Erebus on the southern slopes of the volcano of Mount Bird.

Mr. C. S. Wright, physicist to the expedition, brought back from near the Cloudmaker mountain on the Beardmore Glacier a fragment of limestone containing a small but absolutely perfect and complete coral. This single specimen will probably throw much light on the exact age of these limestone beds.

Glaciology, physiography and the general geology of the Ross region of Antarctica will have greatly gained as a result of the Scott expedition.

In regard to meteorology, a summary has already been given by my predecessor in this office, of Dr. Simpson's investigations of the temperature, pressure and wind directions in the upper atmosphere near Mount Erebus up to levels of nearly five miles. These observations, together with the usual low level records, will have their value

much enhanced by the fact that contemporaneous observations were being taken by Captain Amundsen's party at Framheim, and by Dr. Mawson's party at their main base at Adelie Land as well as by Dr. Mawson's party under Mr. Frank Wild at Termination Glacier, 1,300 miles west of Dr. Mawson's head quarters, and also by Lieut. Filchner's party near Coat's Land.

In regard to biology it is also known that very important specimens have been secured by Mr. Lillie and Mr. Cherry Garrard, a specially fine collection being secured of that rare form *Cephalodiscus*.

Important oceanographic and hydrographic work has been done on board the "Terra Nova" by Commander Evans and Lieutenant H. Pennell as well as by Mr. E. W. Nelson near Mount Erebus in McMurdo Sound.

In reference to the scientific results of the Mawson expedition it may be noted that Mr. C. T. Madigan (Rhodes Scholar of Adelaide University) in a fine journey to the east of Commonwealth Bay, discovered underneath a capping of black columnar basalt rock—600 feet thick—a a large sandstone formation with bands of coaly shale with obscure plant remains. There can be little doubt that this is a continuation of the Beacon Sandstone of the South Victoria Land region. This newly discovered land by the assent of His Majesty has now received the name of King George V. Land. Thus the Beacon Sandstone formation has now been proved to extend over no less a distance than upwards of 1,100 miles. It is not yet known for certain whether the seams are of workable value, though it is known that coal does occur in them of a workable quality. This great formation therefore offers possibilities of being perhaps one of the largest undeveloped coalfields in the world. At the same time if one may judge of the conditions of the coal formation in the Antarctic, from

those in the Argentine and Southern Brazil in Lower or Middle Gondwana time, these would suggest that conditions were not favorable for the formation of pure seams of coal of any great thickness so far south during those epochs. Nevertheless the fact must not be lost sight of that it is quite possible that after all the Beacon Sandstone formation may be of Upper Gondwana (Jurassic) or even of Cretaceous age.

Rich collections of minerals, far exceeding in variety and development anything which previously has been obtained from the Antarctic Continent, have been brought back by Mr. S. F. Stilwell, M.Sc., the geologist in charge at Dr. Mawson's head-quarters. Altogether about a ton of specimens has been secured. These comprise (in addition to minerals such as garnet, scapolite, tourmaline, beryl, apatite and magetite, etc.) metallic minerals also, of commercial value, such as for example molybdenite, antimonite and carbonates of copper.

In regard to glacial conditions at Dr. Mawson's main base it would seem as though the ice sheet has been retreating rapidly there in recent times, inasmuch as low hills of gneiss and schist at the head-quarters at Commonwealth Bay show a beautiful fresh glaciated surface, the striæ being in a perfect state of preservation. When one considers that frost-weathering due to rapid changes of temperature between night and day quickly destroys by splintering any freshly exposed rock surface, it is evident that these glaciated rock surfaces have been very recently uncovered through a retreat southwards of the great ice sheet. This retreat is taking place in spite of the fact that this portion of the Antarctic ice-cap is more plentifully nourished with snow from all its areas further south to the west of Mount Erebus etc. Here, one must note that it does not necessarily follow, as Mawson has shown, that

because the snowfall is heavier in any part of the Antarctic regions than elsewhere, that the glaciers should be at a maximum. It is all a question of addition and subtraction. The extra snowfall near Commonwealth Bay as compared with that near Mount Erebus is perhaps more than compensated for by the extra violence of the wind at Adélie Land. Mawson's records showed that for 1912 the average wind speed throughout the year was fully 48 miles an hour, velocities of 100 miles an hour being frequently attained. These furious winds not only sweep away any fresh fallen snow but tear up and transport seawards the old snows, leaving the surface of the inland ice-table furrowed by sastrugi.

The journey towards the South Magnetic Pole area by Lieutenant Bage with Messrs. S. N. Webb and J. F. Hurley has yielded results of great importance in regard to accurate location of the South Magnetic Pole. Webb established observing stations at every 10 miles along their journey of about 300 miles from their winter quarters towards the Pole, and thus obtained a series of absolute readings with an accuracy most remarkable in view of the extremely difficult climatic conditions. These observations show very strong local variations in magnetic force as in several instances Webb found that as he got nearer to the South Magnetic Pole the dip of the magnetic needle locally became less instead of greater. On the whole he found that the dip increased towards the Magnetic Pole at the rate of about one minute (1′) of arc for every 3 miles. According to his deductions the approximate position of the N.W. edge of the South Magnetic Pole area, on December 19, 1912, was situated in about latitude 70° 36′ south, longitude 148° 12′ east.[1] This differs considerably, in

[1] Mr. E. N. Webb's provisional conclusions, subject of course to corrections when all the observations are reduced and correlated, are that the diameter of the area of vertical needle, in a S.W. N.E. direction, is appoximately about 40 miles, and that its mean centre at the above date was about lat. 70° 52′ S., long. 150° 21′ E.

fact by over 100 miles, from the position assigned to the south-east boundary of the area by Professor David and Dr. Mawson on the Shackleton expedition on 16 January, 1909. One must conclude either that the area of the vertical needle has a width of about 100 miles—(there can be little doubt that it must have a width of at least 30 or 40 miles)—or that Shackleton's Magnetic Pole party did not reach the exact mean position of the area of the vertical needle, or that the whole area, if not more than 40 miles in diameter has travelled to the North-west for a considerable distance since January 1909. When these results are all elaborated and correlated, together with the few magnetic observations taken on the Shackleton expedition, it will certainly be possible to locate very closely the position of the South Magnetic Pole in 1912. As it was frequently necessary to leave Mr. Webb alone in the tent when he was making his observations, his comrades Bage and Hurley had meanwhile to dig for themselves a cave in the hard snow in order to shelter them from the furious blizzard wind. All three therefore endured great hardships, and it is well-known that on the return journey they all but forfeited their lives in consequence of missing the depôt through thick blizzard weather. Mercifully, like Dr. Mawson himself on his terrible retreat after the tragic loss of his comrades Lieutenant Ninnis and Dr. Xavier Mertz, their lives were preserved, and it has been permitted them to bring back results of priceless value to science.

In the department of biology a large number of valuable collections have been obtained by Mr. J. Hunter, who was assisted by Mr. C. F. Laseron. Collections have also been gathered by Mr. Edgar R. Waite and Professor Flynn on separate cruises of the "Aurora," in intervals between her first and second voyages to Antarctica. About 250 miles of new coast line have been charted in this region. Invaluable work in this respect has been rendered by Mr. J.

Van Waterschoot Van der Gracht, the brother of the Government Geologist to the Netherlands, who has placed his unique skill as a cartographic artist entirely at Dr. Mawson's disposal. The scientifically accurate and artistically beautiful sketches which he has brought back and now presented to the University of Sydney, will be an invaluable historic record of the general appearance and condition of the Antarctic coast at the time of his visit at the beginning of 1913.

One of the greatest triumphs of Dr. Mawson's expedition has been the establishment of wireless communication with his subsidiary base at Macquarie Island. The Australasian Wireless Company supplied all the necessary apparatus at generous rates, special attention being most kindly given by Mr. H. Leverrier to the requirements of the expedition.

The general installation of the wireless apparatus was in charge of Mr. W. H. Hannam, who was the first to transmit a wireless message from Antarctica to the outside world. The receiving apparatus was not equally successful at first. On October 13, 1912, one of the masts blew down in a gale in which the wind velocity reached 97 miles an hour. There was no opportunity for repairing this mast until the arrival of the "Aurora" in January of this year. On this occasion the sailors of the "Aurora" added 25 feet to the stump of the old mast already 90 feet in height, thus making the total height 115 feet. At the same time two pieces of the other broken mast were erected respectively 30 feet and 35 feet high close to the 115 feet mast, and an umbrella aerial was then stretched between. It being necessary for Mr. Hannam to return to Australia, Mr. Jeffryes, formerly wireless operator on the "Westralia" took his place, and was the first to receive wireless messages in Antarctica. Since then the wireless has been working quite successfully except when atmospheric conditions are abnormally bad,

and we may confidently expect to be in almost daily communication with Dr. Mawson for the rest of his sojourn in Antarctica. It is no less wonderful than true that some of Mawson's messages are heard direct in Sydney all the way from Antarctica, and this result is attained with a installation of only two kilowatt power.

This is not only a triumph for the Australasian Antarctic Expedition and for all those who were concerned in the wireless installation, including Sawyer and Sandell, the wireless operators at Macquarie Island, but in view of the Roaring Forty Winds, and the most formidable low pressure atmospheric trough in the whole world which these messages have to cross, it is a signal triumph for wireless telegraphy, in every way worthy of being singled out as a subject for special congratulation by His Majesty the King in his recent wireless message to Mawson.

The geographical exploration under conditions of extreme hardship and peril, accomplished by Mr. Frank Wild and his parties, comprising Dr. Sydney Jones, Messrs. A. D. Watson, G. H. S. Dovers, C. A. Hoadley, C. T. Harrison, A. L. Kennedy, and M. H. Moyes, yields in no respect to the best type of exploration in other parts of Antarctica where similar climatic conditions obtain.

Coast lines and islands entirely new to science have been mapped for a distance of 300 miles, and meteorological and glacial observations of great interest and value have been recorded. Nor must we overlook the splendid voyages accomplished by that modest, and, while the youngest certainly not the least successful of Antarctic navigators, Captain J. K. Davis. Amongst other scientific results such as the charting of new coast lines, he has discovered what may be termed an Australian "Atlantis" in the large submarine bank 250 miles south of Tasmania. Moreover he

has obtained material by sounding for a section of the ocean floor all the way from Adèlie Land to Tasmania.

Of all the scientific observations the meteorological are likely to prove of the most direct economic value to Australasia, partly as regards those taken in Antarctica, but chiefly in reference to those recorded by Mr. Ainsworth at Macquarie Island. Mr. H. A. Hunt, the Federal Meteorologist, has emphasized the great importance of the daily weather conditions "Wirelessed" to him from Macquarie Island, for the proper understanding of Australian Weather. It is hoped that as urged, both by Australian and New Zealand scientists and others, the Federal Government will see its way to establish the Macquarie Island Meteorological Wireless Station on a permanent basis. The cost in money, in toil, and alas! in human life, of these Antarctic expeditions, has of late been very great, but while we mourn the loss of the brave who have given their lives for the advancement of science, we cannot but feel thankful that these men have played the game so well and worthily, and that the world of science will be the richer for all time, because of their deeds. Surely the verdict of posterity will be that this Australasian expedition of Dr. Mawson has proved that in courage, hardihood, self-reliance and ability the Australian can hold his own in Antarctica with the men of any other nation, and that the rich harvest of scientific results already reaped, justify all the suffering and sacrifice this expedition has entailed.

I wish to express my grateful thanks to Professor T. W. Edgeworth David, C.M.G., F.R.S., etc., for kindly supplying me with the above valuable notes on the scientific results obtained in Antarctica.

We are now looking forward with the greatest interest to the return of Dr. Mawson and his six companions next summer to learn of the further scientific work which is being carried on in that great white land.

Before vacating the Presidential Chair I would like to express my gratitude, and also that of the Society, to the Honorary Secretaries, Mr. J. H. Maiden, F.L.S., and Professor Pollock, D.Sc., as well as to the Honorary Treasurer Mr. D. Carment, F.I.A., and the Acting Honorary Treasurer Assistant Professor Chapman, M.D., for the valuable service which they have rendered to the Society in looking after its best interests. It is during a President's year of office that he finds how many matters have to be attended to by these honorary officers, and I desire to record my personal appreciation of their united assistance to the Council in successfully guiding the Society's affairs during the past year.

Development and Distribution of the Genus Eucalyptus.

Among the various fragments of evidence which are available to assist us in writing up the climatic, physiographic, and to some extent the geological history of Australia from early Tertiary up to the present day, that supplied by a study of the development and distribution of the genus Eucalyptus should be amongst the most important, seeing that with the exception of a few species found in the islands to the north, the genus is wholly Australasian. The subject is a gigantic one, and in this address I only propose to briefly outline some of the features of distribution which apply more particularly to South Eastern Australia.

At the outset I wish to express my indebtedness to Mr. E. C. Andrews, for much useful information obtained during many conversations, and also from his writings in regard to physiographic changes in Eastern Australia.[1] I have also to acknowledge valuable help on the general subject

[1] "Geographical Unity of Eastern Australia," E. C. Andrews, B.A., this Journal, Vol. XLIV, p. 420, (1910).

from a perusal of the writings of Baker and Smith,[1] Bentham,[2] David,[3] Deane,[4] Hedley,[5] Hooker,[6] Jensen,[7] Maiden,[8] and Mueller.[9] I also wish to thank Mr. Maiden for granting me access to his unpublished drawings of a large series of anthers, which show the great amount of variation that exists in this important part of the inflorescence. My thanks are also due to Mr. W. S. Dun, Palæontologist, Department of Mines, for references to literature relating to Tertiary fossil leaves.

Factors which regulate development and distribution.

Broadly speaking, the factors which play the important parts in regulating the development and distribution of plants are:—Physiography, Geology, and Climate.

Physiography.—The topographic conditions of any country are of extreme importance in their influence upon the distribution of its flora. Where the country is level over a large area, the conditions in regard to rainfall and climate are likely to remain much the same over such area. A range of mountains may give not only the elevation

---

[1] "A Research on the Eucalypts," by R. T. Baker, F.L.S., and H. G. Smith, F.C.S.

[2] "Flora Australiensis," by George Bentham, F.R.S., etc.

[3] "Geological Notes on Kosciusko, with Special Reference to Evidences of Glacial Action," by T. W. Edgeworth David, B.A., F.R.S., etc., Proc. Linn. Soc. N.S. Wales, Vol. xxxiii, p. 668, (1908).

[4] "Observations on the Tertiary Flora of Australia," by Henry Deane, M.A., F.L.S., etc., Proc. Linn. Soc. N. S. Wales, Vol. xxv, (1900). Presidential Addresses, Proc. Linn, Soc. N.S. Wales, 1895 and 1896.

[5] "Presidential Address," by C. Hedley, F.L.S., Proc. Linn. Soc. N. S. Wales, Vol. xxxvi, (1911).

[6] "Flora of Australia, its Origin, Affinities and Distribution," (1859) by J. D. Hooker.

[7] "Soils in Relation to Geology and Climate," by H. I. Jensen, D.SC., Department of Agriculture, N.S. Wales, Science Bulletin No. 1, 1911.

[8] "A Critical Revision of the Genus Eucalyptus," also various papers in Proc. Linn. Soc. N.S. Wales by J. H. Maiden, F.L.S.

[9] "Eucalyptographia," by Baron von Mueller, 1879–1884.

necessary to produce a cooler climate, but when fringing the ocean with extensive low areas on the side opposite the ocean, it provides two separate aspects totally distinct in character, one being moist while the other is dry. Deep gorges are also developed in the mountain sides and the flora of these differs from that of the adjoining hills.

A study of the physiography and the geology of South Eastern Australia, serves to show that in early Tertiary time, this area was chiefly a low tableland or peneplain,[1] only a few hundred feet above sea level. Such physiograpic conditions would have had the effect of producing a fairly uniform climate over the greater portion of this area,[1] the rainfall would have been more evenly distributed, with the result that there would have been a much greater similarity in the flora for two or three hundred miles inland than is the case at the present day. During Tertiary time some minor upheavals took place, but towards the close of the Tertiary Period, or what Mr. Andrews calls the Kosciusko Period, a range of mountains paralleling the coast at an average distance of 70 – 80 miles therefrom, was uplifted to elevations varying from upwards of 2,000 – 7,300 feet above sea level, and with some slight modifications these features remain to the present day.[2]

The effect of this last uplift upon the flora of South Eastern Australia is most marked, for, as is well known, instead of one uniform flora extending back from the ocean a distance of, say, 200 miles, there are now three, and what was the original or typical one, as evidenced by the fossil leaves in the Tertiary drifts on the western portions of the present mountains, is now most nearly represented by portions of that confined to the coastal strip.

---

[1] "Geographical Unity of Eastern Australia," E. C. Andrews, this Journal, pp. 421 and 453, (1910).

[2] See Relief Map of Australia, Presidential Address by Professor David, this Journal, Vol. XLV, Plate I, (1911).

Geology.—The effect of geological formations upon the distribution of plants, though distinctly evident in many localities, is to some extent of a local nature, being dominated by the influence of climate. Broadly speaking the Eucalypts distribute themselves under two extreme types of geological formations, the siliceous and the basic, and there are numerous examples of two distinct floras approaching each other up to a common boundary without intermingling, the one growing perhaps on an acid granite or siliceous sandstone formation with an abundance of free silica, and the other on a basalt or other basic rock, producing a clay soil.

Although certain trees show such a distinct preference for either a basic or a siliceous formation, it is difficult to ascertain the exact reason for this discrimination. In studying the analyses of a series of rocks, it is noticed that broadly speaking, the ferro-magnesian constituents increase as the silica decreases, and the basic rock therefore produces the more chemically-rich soil; while on the other hand those granites with a high percentage of silica are usually richer in potash than are the basic rocks. The proportion of soda, however, has no regular gradation according to either increasing or decreasing quantities of silica, but of the two types of rock, the soda usually occurs more plentifully in the basic than in the highly siliceous. Apart from the question of the chemical constituents there is that of the mechanical condition of a soil, and it seems undoubted that in certain cases the physical characters are of greater importance to the plant than the chemical constituents. It is of course those rocks with a high percentage of free silica which so largely affect the physical characters of the soil, and furnish it with capillary properties, so that when a plant exhibits a definite preference for a highly siliceous formation it may be that it neither wishes to avoid some constituent which occurs in a large

proportion in the more basic rocks, nor that it prefers something which is only formed in the highly siliceous, but rather that the porous state of the soil allows the moisture to reach the plant, and so enables it to avail itself of the particular food it requires.[1]

It is unquestionable that primarily the soil of any particular area is largely the product of the decomposing geological formation in the locality, and the constituents of the rock may be ascertained by analysis of sound freshly fractured portions of it. By constantly observing the class of rock selected by certain species, some of which show very distinct preferences, information may be obtained which would be of the greatest value in the selection of sites for fresh plantations, and species which favour either basic or siliceous rock-types could be planted in the formations which during the test of ages in Nature's laboratory they have found to be congenial.

The soils produced from similar geological formations in separate localities have not always the same effect upon the local flora, the diversity being caused by the differences in climate, rainfall, and aspect; but in areas where these conditions remain the same, certain Eucalypts are typical of particular geological formations. Examples in the Sydney district may be seen in the distinct preference shown for the siliceous Hawkesbury Sandstone formation by *Eucalyptus corymbosa*, *hœmastoma*, *capitellata*, *Sieberiana*, *piperita*, etc., and in *E. hemiphloia* and *tereticornis* for the Wianamatta Shale, which contains a much lower percentage of free silica. In the mountain areas the same discrimination is exercised by various Eucalypts in the selection of formations. The presence of *E. Andrewsi* and *Bancrofti* may be taken as evidence

[1] See "Œcology of Plants," by Eug. Warming, PH.D., p. 70 (English Edition) 1909,

that the rocks amongst which they are growing, contain upwards of 70% silica, much of which is in a free state, while *E. viminalis*, *nova-anglica*, and *stellulata*, growing perhaps only a few hundred yards away, usually indicate that there is less than that amount of silica in the formations which sustain their growth. But in dealing with the acidity and alkalinity of soils produced from the same type of rock in various localities, the question of the local rainfall and topography must be considered, for it will be at once apparent that a decomposing alkaline rock in a dry climate will furnish a soil containing a higher percentage of alkali than will be produced by a similar rock in a wet climate, for the reason that in the wet area the soluble alkali will be more readily leached out, and some of it washed away. The difference in the alkalinity of the resultant soils will be accentuated if the moist area is in mountainous country and the dry locality on the level plains, for in the former case the alkali is readily washed away after leaching out, and in the latter, both operations are retarded. The question however, is one that has to be considered with caution in view of other factors which may sometimes operate.

In order to ascertain what are the various constituents and conditions selected by certain plants, a botanical survey should be carried out in conjunction with a soil survey, and analyses made of the soil and rocks which furnish the nourishment for the particular species under investigation. Details should also be obtained of the climate, rainfall and aspect of the area surveyed. When this is done for New South Wales, we shall know why distinct preferences are so often shown for particular geological formations.

It seems not unreasonable to suppose that the two extreme types of rock, acid and basic, which furnish very

distinct forms of nutriment, should exercise some important influence in the evolution of species.

Climate.—Undoubtedly the dominating influence in regulating the distribution of any flora over a large area, is climatic, and this in itself is determined by the latitude, elevation, rainfall and aspect. The whole of the Eucalypts in Australia and Tasmania occur approximately between the latitudes of 11° and 44°, while those on the mainland of Australia extend from about the latitude of 11° to 39°. So far, therefore, as the mainland is concerned, if we can in imagination reconstruct it as a peneplain only a few hundred feet above sea level, as geologists believe was the case in early Tertiary, we can see that the climate under present day conditions would have been a mild to a warm one. We have evidence from the remains found of large, somewhat unweildy, animals such as the Diprotodon, which from their structure must have lived on level marshy country, that the climate was then a fairly damp one. It is well also to remember that at this early period Tasmania formed part of the mainland. From available evidence it would appear that Eucalypts north of latitude 35°, which to day are restricted to elevations above 2,000 feet, could have had no existence in New South Wales north of that latitude, in their present form, under Eocene and perhaps Miocene conditions. Examples of such Eucalypts are supplied in *E. coriacea*, *stellulata*, *dives*, *vitrea*, and *amygdalina*.

The final uplift towards the close of the Tertiary, the Kosciusko Epoch, changed all this. The resultant Main Divide not only separated the original uniform climate into three, but with its fairly steep eastern face presented to the ocean, it created moister conditions over the coastal area, and with its mountain elevations, which reach up to 7,300 feet, it provided the cool conditions necessary for the growth of Eucalypts which previously may not have existed

north of latitude 35°, but which in a few cases are now found as far north as latitude 29°, or just to Queensland, examples being supplied by *E. coriacea, stellulata* and *amygdalina.*

The effect of this uplift, upon the western side of the Main Divide, has been to produce a drier, as well as a hotter summer and colder winter climate, and the Eucalypts in response to this change have gradually adapted themselves to the new conditions with the result that they differ considerably from many on the coast, but most of all from those on the higher mountains.

Glacial Period.—A most important influence which must have done much to test the cold-resisting capabilities of Eucalypts was the refrigerating period in Post Tertiary or Pleistocene time and of which there is abundant evidence on Mount Kosciusko to-day.[1] It is generally believed that this glacial action, owing to its universality, was the result of temperature change, and not due to any local alteration of mountain levels. In a paper read before the Linnean Society of New South Wales *(supra)*, Professor David has stated that during the glacial period referred to, the snow-line which is now considered to be at about 8,000 feet in the Kosciusko district, came down about 3,000 feet (printed 300 erroneously). Assuming that the snow-line came something between 2,000 and 3,000 feet lower than its present position, a consequent lowering of the temperature of 7° to 10° Fahr. would be involved.

The effect of this refrigeration upon all vegetation must have been considerable, and it seems reasonable therefore to expect some modification of plant characters as a result. Since the closing of the Pleistocene glacial period, climatic

---

[1] Geological Notes on Kosciusko, with Special Reference to Evidences of Glacial Action, by Professor David, F.R.S., Richard Helms, and E. F. Pittman, A.R.S.M., Proc. Linn. Soc. N.S. Wales, Vol. XXVI, (1901).

conditions appear to have remained practically as we find them to-day. In a paper on the flora of the Nandewar Mountains I have briefly discussed the possibilities of cold-loving plants having migrated north during this glaciation and of their having become stranded upon its termination.[1]

Modification of the Eucalypts in New South Wales since the Kosciusko Period.

In order to fully appreciate the possibilities of modification and development of the Eucalypts subsequent to the great uplift in Pliocene time, it is necessary to keep foremost in mind at least three important points. The first of these is that before this great tectonic movement took place, South Eastern Australia was a much more level country with a fairly uniform climate. The second point to be kept in the foreground is that the available geological and physiographic evidence implies that the upward movement though gradual, was comparatively rapid, especially where the elevations are greatest,[2] but was of sufficient duration to allow much of the vegetation to adapt itself to the new conditions. A measure of the movement is supplied from the fact that pre-existent rivers, in some cases, were enabled to cut down their channels and thereby retain their original courses while elevation was in progress.[3] The third factor to be remembered is the Pleistocene glacial period.

As a uniform climate implies a fairly uniform flora, it would seem that a just conclusion to be arrived at from a contemplation of these various factors and conditions would be that immediately prior to the uplift, the differences in New South Wales, amongst those Eucalyptus characters

[1] Proc. Linn. Soc. N.S. Wales, Vol. xxxvii, (1912).

[2] "Geographical Unity of Eastern Australia," by E. C. Andrews, this ournal, Vol. xliv, p. 461, (1910).

[3] "Notes on the Geography of the Blue Mountains," by E. C. Andrews Proc. Linn. Soc. N.S. Wales, Vol. xxix, p. 812, (1904).

which are chiefly the result of climatic effect, were much less pronounced than is the case at the present day. Having in view that the earth movement was gradual, a consequential result would have been that many plants would have responded to the various changes and accommodated themselves to the new conditions. But it does not follow that all would have succeeded in so doing, and amongst the successful ones there should be examples of varying degrees of success to be met with at the present day. Those Eucalypts which survived the great uplift had subsequently to endure a period of greater refrigeration than any they had previously encountered, and it is the resultant modified forms which constitute so much of the present Australian flora. The characters adapted or constituents formed for purposes of preservation towards the close of the glacial period, would be likely to remain fairly constant in the various plant-zones, so far as climatic effect is concerned, to the present time.

Climatic Divisions.

Having very briefly outlined the great causes which acted as forces in regulating the changes and development of the flora of South Eastern Australia, it will now be instructive to examine some of the effects.

At least three distinct type-areas of vegetation have been produced, viz.:—the Coastal or semi-jungle, the Mountain or cold-type, and the Interior or semi-arid; and owing to physiographic considerations a fourth, which in a previous paper I have referred to as the Western Slopes, may be added.[1]

Coastal Area.—The features of the Coastal Area may be described by saying that its eastern side is flanked by the ocean, while its western boundary, ranging from 35 –

[1] "Climatic and Geological Influence on the Flora of N. S. Wales," by R. H. Cambage, Report Aust. Assoc. Adv. of Science, Vol. xi, p. 476, (1907).

100 miles away, is formed by the steep mountain chain which averages from 3,000 – 4,000 feet high, and in places reaches 6,000 – 7,000 feet. With an annual rainfall of from nearly 40 and up to 60 inches from south to north, gorges are being cut into the elevated parts by denudation, and in the deep valleys thus formed, conditions of shelter and moisture combine to produce trees, some of which are amongst the tallest in the world. A feature of the Coastal Area is its humid atmosphere, and this is partly the result of the Kosciusko uplift, which had the effect of shutting off a considerable percentage of ocean moisture and rainfall, which previously would have penetrated much further westward than at present. The result is a drier climate in the Interior towards which the summer heat causes the moisture-laden north east wind to blow, the moist effect of which however is largely intercepted by the eastern face of the mountains, thus increasing the humidity of the Coastal Area.

It seems undoubted also that the presence of the warm Notonectian current,[1] which flows past the coast of New South Wales, also contributes to this humidity, for it has been noticed that certain plants which avoid the ocean side of the Main Divide in this State, flourish on the southern or ocean side of the prolongation of the same range in Victoria, beyond where the effect of this current reaches.

It is in this division that the conditions are found which should most nearly approximate those of Miocene time in South Eastern Australia. Nor is evidence wanting that such an assumption has good grounds for support, because it is well known that the Tertiary fossil leaves which have from time to time been discovered in the Mountain Region and on the Western Slopes, resemble those of the present Coastal Area more than those of any other plant-zone.

---

[1] See Presidential Address by C. Hedley, F.L.S., Proc. Linn. Soc. N. S. Wales, Vol. xxxv, p. 10, (1910).

Mountain Region.—The Mountain Region with a rainfall ranging from about 20 – 60 inches annually and an average of about 34 inches, contains generally the softest Eucalyptus timbers. It is in this area that we should look for the greatest divergence from original types especially in the vegetative shoot, for it is here that during the process of the uplift and subsequently, that the most severe changes were encountered, and the greatest demand would be made upon the plants to adapt themselves to their environment. Much of the Mountain Region ranges from 3,000 – 4,000 feet above sea level, the culminating point on Mount Kosciusko being 7,328 feet in latitude 36½°. So far, however, no Eucalypt has been able to adapt itself to the cold exposed conditions of this latter altitude, the greatest elevation reached by *E. coriacea* being about 800 feet short of the summit.

Western Slopes.—The Western Slopes division contains a flora which forms a sort of connecting link between that of the Mountain Region and the Interior. In New South Wales, except in the extreme south, the western side of the mountains is not so steep as that of the eastern face, but falls gradually away in long slopes forming a zone paralleling the Main Divide, and into the upper edge of which certain mountain plants descend, while the lower margin, where it joins the great plains, is the home of some of the Interior vegetation. There are certain species however, such as *Eucalyptus albens*, that are typical of this zone, which in New South Wales has an annual rainfall of about 26 - 27 inches.

The Interior.—In the Interior the conditions are dry, the rainfall ranging from about 10 – 20 inches annually, the average amount being 13 – 14 inches. From investigation of the Tertiary fauna of parts of this area, as shown by fossil remains, the rainfall and moisture over this division

were apparently greater before the Main Divide shut off the coastal influence in the Kosciusko period than at present. Here we look for evidence of plants having devised means of adapting themselves to drier conditions, but the change in the vegetative form over this area should not be so great as that of the Mountain Region, where all the factors have operated to make the extremes greatest between early Tertiary and present day conditions.

Grouping of Eucalypts.

In attempting to arrange the various Eucalyptus species into groups which represent certain special features, the difficulty is encountered of deciding upon the line of demarcation between characters which closely approach each other. In the present discussion the subject of grouping is only treated on general lines which are sufficient however to show that certain features are usually the result of a particular climate, aspect, or geological formation, or of a combination of these various factors, although in some instances the exceptions to what appear to be general rules are, in the light of our present knowledge, most marked and perplexing.

For the purpose of grouping, an investigation of some of the following features is instructive:—

Barks—smooth, scaly, scaly to subfibrous, fibrous, and hard-furrowed.

Timbers—texture and colour.

Leaves—size, thickness and venation.

Anthers—parallelantheræ, porantheræ, and renantheræ.

Oil constituents—pinene, eucalyptol (cineol) and phellandrene.

Barks.

For the purpose of discussing the distribution of various kinds of bark, only well marked types have been selected, between each of which there are insensible grada-

tions. I have not included the hemiphloiæ or half-barked section, because this designation gives no clué whatever to the nature or texture of the bark on the lower portions of the boles, and this character of rough bark occurring on the trunk in varying extent, with smooth branches, may be found distributed in some measure throughout most of the sections.

There are so many gradations in the textures of the Eucalyptus barks, that it is impossible to account for them all in detail within the limits of five sections, and in a few cases a particular class of bark may be almost equally distributed over two climatic divisions.

In considering the allocation of the sections in New South Wales the following four geographical divisions will be referred to viz.:—the Coastal Area, the Mountain Region, Western Slopes and Interior (See Plate I). In the following table the word "first" signifies "most abundant," and fourth denotes "least abundant" in the particular division under which the number appears.

Barks.	Coastal.	Mountains.	Western Slopes.	Interior.
Smooth	Second	First	Third	Fourth
Scaly	First	Fourth ?	Second	Third ?
Scaly to sub-fibrous	Third	Fourth	Second	First
Fibrous	First	Second	Third	Fourth
Furrowed	First	Fourth	Second	Third

Smooth Barks.—The smooth barks, which include such trees as *Eucalyptus viminalis* and *E. coriacea*, are perhaps more typical of the Mountain Region than any other, with the Coastal Area ranking a close second. It seems remarkable that as the ascent is made, especially above 4,000 feet, and the more rigid climatic conditions are encountered, the Eucalypts, particularly if growing in the open, instead of being more densely coated with thick fibrous bark, are gradually restricted to the smooth-barked types, such as

E. coriacea and *rubida* in New South Wales and Victoria, and *E. Gunnii*, *coccifera*, and *vernicosa* in Tasmania. This goes to show that the actual protective qualities of the bark are not wholly regulated by the texture, but also depend upon the constituents contained in the bark.

Scaly Barks.—Among the scaly-barked Eucalypts of which *E. corymbosa* of the Bloodwood group may be considered as a type, there are various gradations, and the section may be extended to include such trees as *E. robusta.* This class of bark, which is something between a scaly and a woolly, probably most nearly represents that of the earliest type of Eucalypt, and is most plentiful in the Coastal Area, next on the Western Slopes, and least in the Mountain Region.

Scaly to sub-fibrous.—In the sub-fibrous class, or what is a sort of transition from scaly to shortly-fibrous, we have amongst others *E. populifolia* and *E. hemiphloia* of what are known as the Box-tree group, the bark of which is usually of a grey colour. The fibre is very short, the bark not particularly thick, and usually covers most of the trunk and often the branches as well. The Box timbers are very hard, and like the Ironbarks, this class of Eucalypt absolutely shuns the colder situations, neither group having a representative in Tasmania. The Box-tree section is most common in the Interior and next to that, on the Western Slopes, occurring also in the Coastal Area, but absent from the mountains above an altitude of 3,000 feet in latitudes south of 32°.

Fibrous Barks.—The commonest forms of fibrous-barked trees are known as Stringybarks of which *E. eugenioides* and *E. obliqua* may be mentioned as types. Most of these Stringybarks occur in the Coastal Area, and next in the Mountain Region, while there is only one species, *E. macrorrhyncha* on the Western Slopes, and except for an occasional

tree of the last mentioned species, the fibrous-barked Eucalypt is unknown in the Interior. This distribution is of great interest and appears to be in response to climatic conditions. A second form of fibrous bark which is less stringy than the typical Stringybarks, and usually of a grey colour, is known as Peppermint-bark from the fact that the species on which it grows possess leaves which emit a strong odour of peppermint when crushed. The Peppermint group, of which *E. dives*, *Andrewsi*, *amygdalina*, and *piperita* are typical, belongs chiefly to the Mountain Region, and occurs also in the Coastal Area, but is absent from both the Western Slopes and the Interior, in fact, to an observer descending the western side of the mountains, the presence of the Peppermints is evidence that cool conditions have not yet been left behind, while the occurrence of the Box-trees denotes that the country below the margin of the winter snow has been reached, and that fairly warm and comparatively dry conditions prevail. Three of the typical Peppermints, viz., *E. dives*, *amygdalina* and *Andrewsi* rarely if ever descend below an altitude of 2,000 feet in latitudes north of 35°, so that it seems probable that prior to the great uplift in the Kosciusko period, these species, in their present state of development did not exist in New South Wales except perhaps in the extreme south, and this latter possibility could apparently only apply to the first two.

Furrowed Barks.—The hard furrowed-barked trees of which the Ironbarks, *E. crebra* and *E. sideroxylon* may be regarded as types, are most numerous in the Coastal Area, and next to that, on the Western Slopes, being practically unknown in the Mountain Region above an altitude of 3,000 feet. It seems curious that the one condition these hard-timbered thick-barked Eucalypts avoid more than any other, is the cold. One species with equally

rough furrowed bark on the trunk, but with softer fissile timber, viz.:—*E. Sieberiana*, which belongs to the Mountain Ash group, flourishes from sea level up to an elevation of about 3,500 feet on the ocean side of the mountains but is almost unknown west of the Main Divide. *E. Smithii* is another species with furrowed bark on the lower part of the bole, and is found east of the Main Divide below an altitude of 3,000 feet.

Timbers.

These may broadly be grouped under two heads viz.:—Texture and colour, the former of which may be subdivided into hard and soft, and the latter into dark and pale. In arranging Eucalyptus timbers into hard and soft groups it is found that the hardest occur in the Interior where the conditions are the most arid and the trees of slowest growth, though the hardest are not necessarily the strongest. The second in degree of hardness are found on the Western Slopes, the third on the Coastal Area, and the fourth or softest in the Mountain Region. The Coastal Area contains both hard and soft Eucalyptus timbers, members of the Ironbark group such as *E. paniculata*, *siderophloia* and *crebra*, also *E. hemiphloia* of the Box group being amongst the hardest. It might perhaps be expected that the decrease in hardness would accord with the increase in rainfall, but although this progression applies so far as the Interior and the Western Slopes are concerned, it is in the division with the third highest rainfall and not the fourth, viz., in the cold Mountain Region where there are the least hardwoods.

In studying the dark and pale coloured timbers, it is noted that in the warmer parts both colours occur, while in the Mountain Region, above an altitude of 3,500 feet in latitude 32°, and at diminishing elevations to the southward, the prevailing colour of Eucalyptus timbers is pale,

no red-timbered Eucalypt occurring in Tasmania.[1] The colouring of dark timbers is evidently due to the presence of some constituent, perhaps developed in response to a plant food, and it seems not improbable that the development of the substance in question is retarded by the cold. The wood of mountain Eucalypts is also regarded as the least valuable for firewood among the genus, which fact implies some difference in the composition of many lowland and highland Eucalyptus timbers.

Now under the peneplain conditions, long prior to the Kosciusko period, a greater similarity in the texture of Eucalyptus timbers in South Eastern Australia would undoubtedly have existed over at least the Coastal, Mountain, and Western Slopes divisions, and it seems a fair inference that the great uplift in that period is responsible for accentuating, even though an earlier and slighter uplift may have helped to originate, some of the various differences in the textures of these timbers.

Leaves.

Perhaps it is in the leaves of Eucalypts, when the significance of their many and varied forms is better understood, that much of the past history of this genus will be revealed. The leaves may be regarded in a measure as the chemical laboratory and lungs of the tree, and in order to preserve themselves in a fitting manner to carry out their starch-producing and breathing functions, it is well known that the leaves of Eucalypts have become modified in various ways in response to their environment. While they have undoubtedly adopted various means of combating the same injurious influence, on the other hand they have resorted to the same expedient to overcome

[1] Messrs. R. T. Baker, F.L.S., and H. G. Smith, F.C.S., make some reference to this subject in a paper "A Research on the Eucalypts of Tasmania and their Essential Oils," read before the Royal Society of Tasmania in October 1912, Pap. and Proc. Roy. Soc. of Tasmania, p. 139.

distinct effects amidst different surroundings. For this reason therefore extreme caution should be exercised in any attempt to interpret the significance of any particular leaf modification.

The mature or adult Eucalyptus leaves which are often falcate, are disposed vertically in the great majority of cases, so as to present the least possible surface to the sun, and thus minimise transpiration or the vaporising of water which is in the leaf. Eucalypts have also in many cases reduced their leaf surface, while in a few instances they appear to have increased it, as may be seen by a study of juvenile and mature foliage on the same tree, the juvenile foliage being regarded as more nearly representing the ancestral form.

Large and small leaves.—In considering the large and small forms of mature leaves, the former may be regarded as including those which are either long or broad, and the latter, those which are either short or narrow. The largest are commonest in the Mountain Region, the second largest in the Coastal Area, the third on the Western Slopes, and the smallest in the Interior. Having in view the question of adaptability to environment, this distribution is exactly what might be expected, the cool or moist divisions having the largest leaves and the driest area the smallest. At the same time there are exceptions to this general rule, for while the sheltered portions of the Mountain Region produce such trees as *E. globulus* and *E. goniocalyx* with leaves often upwards of a foot long, the more exposed portions are the home of such trees as *E. Moorei* and *E. parvifolia* with narrow leaves from two to three inches long.

Thick and thin leaves.—The thickening of the epidermis for the purpose of sheltering the stomata, is one of the expedients resorted to by the Eucalypts to resist evapor-

ation, and consequently it is compatible with such an endeavour, that those species having the thickest epidermis and of which such as *E. dumosa* may be taken as a type, are commonest in the Interior. But this particular character is to be met with intermittently in all the four climatic divisions of New South Wales, so that it wouid appear that various species have adopted this precaution for preservative objects but from different causes. A dwarfed Port Jackson form of *E. capitellata* has remarkably thick almost orbicular leaves, while large normal type specimens within a few miles have lanceolate foliage of ordinary thickness. The thick-leaved form however grows in the more exposed positions, and in the more rocky situations with probably less plant food available. It seems therefore not improbable that in order to counteract the effect of strong winds, to which its exposure renders it liable, and also to compensate in some way for the limited nourishment it obtains, that the thick-leaved adaptation has been evolved in this case, to preserve the starch which forms in the leaf and which is regarded as an auxiliary food supply. It is of interest to note that the thickest leaved types usually correspond with the more dwarfed forms, and when the same species at maturity occurs both as large and as stunted trees, it is on the latter that the thickest leaves are found.

Turning next to the Eucalypts in the cold climate we find a similar variation in leaf characters. The foliage of *E. Gunnii* as dwarfed trees on Mount Roland in Tasmania at nearly 4,000 feet above sea level, is distinctly thicker in texture than that of the same species around Guildford Junction at an altitude of 2,000 feet, and where the trees are upwards of 80 feet high.

The leaves of *E. coriacea* are always somewhat leathery as the specific name would imply, but in observing trees

of this species from just above the 2,000 feet level around Goulburn upwards to the 6,000 feet level towards Kosciusko, it is found that with the ascent the leaves get gradually smaller and thicker, and the trees become dwarfed from the rigid conditions and weight of winter snow, until at last they appear as gnarled shrubs with interlacing branches and the now thickened leaves have been reduced in length from about 6 to 3 inches.

It therefore appears that the sub-arid conditions of the inland country, and the coldest effects of the mountains, though extreme in their climatic influence, have so operated in regard to this particular phase of leaf character as to bring about the same result. It is suggested however that the modifications of the internal structure of the leaves of two Eucalypts which originated before the Kosciusko uplift, and developed until the present time under those two extremes of climatic influence, would not be the same, and although the leaves of *E. coriacea* at 6,000 feet, have their counterpart in the Interior at 500 feet, so far as the thickening character is concerned, yet in their venation they are distinct from those of all species found in that dry region.

Horizontal and vertical leaves.—The mature foliage of almost all Eucalypts is arranged vertically, and this fact furnishes strong evidence that there must have been considerable development in the genus, for in the great majority of cases the juvenile foliage is arranged horizontally. The same remark in regard to the juvenile foliage applies equally to its nearest allied genus, Angophora. There seems little reason to doubt that the mature foliage also was originally sessile and arranged horizontally, and that the pendant, vertical form is the most recent adaptation. Throughout the genus Eucalyptus there are various species which show a connecting link amongst their mature foliage,

between the horizontal and vertical forms, and in a collection of leaves some of the foliage may be noticed with the underside pale which proves the horizontal disposition of the leaf.

Judging by results, it would seem to have been almost a necessity at some particular stage of Eucalyptus development that some adjustment of leaf arrangement should have been made to conform to some altered climatic condition, and ensure the further progress of the genus. The simplest method for those species to adopt which had already developed petiolate leaves, was to gradually twist the leafstalk and so change the position of the blade from horizontal to vertical. It is instructive to enquire into the condition of one or two species which appear to have been unable to do this.

One of the most interesting Eucalypts in this connection is *E. pulverulenta (E. pulvigera)* which is growing in the Mountain Region at Cox's River, at Bathurst and near Cooma. This tree appears to have been unable to develop any lanceolate leaves at all, or to substitute the alternate for the juvenile opposite arrangement, the whole of its foliage being either orbicular or broadly ovate, and being sessile, the cordate leaves remain clasping the stem at right angles, and therefore present their full surface to the sun. It is now that we see the potentialities of the Eucalypt to adapt itself to its surroundings, and the method selected in this instance has been to cover the leaves with a glaucous powder or vegetable wax which reduces the effect of the sun's rays and therefore lessens the evaporation, while it also serves to keep out the cold in winter. It would seem however, that this provision has not been so successful as the twisting of the leaf-stalk, for this species is a weakling and rarely seems able to grow more than 20 feet high, and although in the past it appears to have had

an extensive range at least from Bathurst to Cooma, a distance of about 200 miles, it is not known in the intervening area, and is looked upon as rare in both localities. The available evidence regarding this tree points to the conclusion that it is probably a vanishing species.

E. cordata of Tasmania is a very similar little tree and has adopted the vegetable wax instead of the vertical leaf. The species is confined to Tasmania and even there is not regarded as plentiful. It seems not unlikely that in the near geological future both these species will have disappeared.

E. cinerea of the Goulburn district is somewhat similar to the two former, but appears to be past the critical stage. It has covered its leaves with glaucous powder, and although some trees are furnished with opposite orbicular and broadly ovate leaves only, others have developed many lanceolate leaves which hang vertically. It grows to a height of 40 or 50 feet, has a fairly considerable range, and its stems are covered with thick shortly-fibrous bark, while the two former have smooth bark.

The remarks in regard to *E. cinerea* apply generally to an interesting species known as Silver-leaved Ironbark, *E. melanophloia*, except that the latter has a hard furrowed bark.

Juvenile leaves.—Under the designation of juvenile leaves may be included not only seedling leaves, but also most of those of certain adventitious growths abundantly produced by cutting or wounding parts of the barrel or branches, and which in Australia are popularly known as suckers, and the difference between these leaves and the mature or adult foliage of the same tree is often so great as to convey the impression to one who has not studied the genus, that they belong to distinct species. It is remarkable that Eucalypts rarely, if ever, produce true botanical

suckers or shoots from the roots, and a careful examination of the young growths which appear around and at some little distance from a standing tree and look like true suckers, results in the discovery that the plants are seedlings.

Between these stem-shoot and seedling leaves there is a great similarity, and as according to the general biological belief it is in the young forms of both flora and fauna that we may expect to find the greatest resemblance to ancestral types, so we may regard these reversion shoots as of almost equal value with the seedlings for the purpose of studying the ancestral forms of Eucalypts. Although the leaves of these "suckers" when available, are of considerable assistance in the identification of many species, they vary within certain limits both in size and shape, possibly in response to differences of climate and to extremes of nourishment and poverty. An interesting feature of their form is the degree of dissimilarity between them and the mature leaves. In some instances the difference is slight and in others exceedingly great. Mr. Andrews has already pointed out that the difference is greatest in the highland and coastal region.[1] In addition to the disparity of shape and size between juvenile and adult foliage, there is also a marked difference in arrangement, with the exception of a comparatively few cases which thereby appear anomalous. In the most diverse cases the juvenile leaves are sessile, opposite and horizontal, orbicular to broadly ovate, and perhaps covered with a glaucous bloom, while the adult leaves on the same tree may be petiolate, alternate, vertical lanceolate and glabrous. There are some species such as *E. dives* and *Risdoni*, which flower while still in the opposite leaved stage, but they eventually develop the alternate lanceolate form. A Eucalypt with the adult

[1] This Journal, Vol. XLIV, p. 467, (1910).

leaves arranged along the branchlets in sessile, opposite pairs at once attracts attention, and it seems remarkable, considering that this appears to have been the form from which the genus has evolved its present foliage, that when this feature is wholly retained as in the cases of *E. pulverulenta* and *cordata*, though in a moist climate, the trees are depauperate and apparently languishing, as if the failure to change their habit in response to some altered environment will result in their extermination; while on the other hand, all the great giants of the genus are amongst those which have developed petiolate, alternate leaves after reaching at most a few feet high. The subject however, is an intricate one, and there are many phases of the question to be investigated and considered before final judgment can be pronounced.

In considering the distribution of those Eucalypts which show the most marked differences between the juvenile and adult foliage, it is found that the extreme forms of divergence are commonest in the Mountain Region, next in the Coastal Area, third on the Western Slopes, and least in the Interior. The elements of temperature and moisture therefore again appear to be important factors in regulating this distribution, and when we consider the association between the region of greatest diversity in leaf-form, and the cold climate, we cannot but realise the important influence which the uplift in the Kosciusko period has exercised on the distribution of the Eucalypts in South Eastern Australia.

Amongst those species which show extreme diversity of form and arrangement between the juvenile and adult foliage in the Mountain Region are the following:—*Eucalyptus rubida*, *viminalis*, *amygdalina*, *dives*, *radiata* (in the lower altitudes), *Smithii*, *globulus*, *Maideni*, *goniocalyx*, *nova-anglica*, *Macarthuri*, *Bridgesiana*, *Cambagei*, *Gunnii*, *Risdoni*, and in some instances *cinerea*.

Other mountain Eucalypts whose seedling leaves are very much larger than their adult foliage, and are opposite for a few pairs only, but are not sessile, are *E. Delegatensis* and *Andrewsi*.

In the Coastal Area some of those species which show the diverse forms and have juvenile leaves both sessile and cordate are *E. quadrangulata*, which ascends the mountain to about 2,000 feet, *E. radiata* which ascends to about 2,500 feet, *E. Smithii* which ascends to about 3,000 feet, *E. umbra*, and *melanophloia* on the Upper Clarence. There are others which show extremes in size but whose seedlings have very few opposite pairs, amongst which may be mentioned some forms of *Eucalyptus tereticornis*, *siderophloia*, *hemiphloia*, and *Planchoniana*.

On the Western Slopes, the Eucalypts which show extreme forms of foliage and have sessile juvenile leaves are *E. melanophloia* in the north, *E. Cambagei* on some of the hills and *E. Bridgesiana* on some of the flats, but the home of the latter two is chiefly on the mountains.

There do not appear to be any species of Eucalyptus in the Interior whose seedling leaves are sessile and cordate, excepting *E. melanophloia*. The form, however, is not wholly absent from some of the dry portions of Australia.

Clothing of Leaves.

Among the familiar forms of leaf coating for the purposes of affording protection are the development of fine hairs and tomentum, the secretion of wax and viscid substances, the coating of the leaf with caoutchouc, and the thickening of the epidermis. Of these methods the Eucalypts of New South Wales chiefly adopt the thickening of the epidermis, the wax covering, and in some instances the caoutchouc coating on the Juvenile leaves.[1]

---

[1] See a paper "On the Elastic Substance Occurring on the Shoots and Young Leaves of *Eucalyptus corymbosa* and some species of Angophora," by H. G. Smith, F.C.S., this Journal, Vol. XLII, p. 133, (1908).

Stellate hairs.—Although stellate hairs are present on the juvenile foliage of some species as pointed out by Mr. Maiden,[1] especially among the Corymbosæ or Bloodwood group and the Stringybarks, this form of covering is rarely so dense on the Eucalypts as to afford much protection, and is probably one of the early devices.

Caoutchouc.—The adoption of the caoutchouc coating by Eucalypts appears to be confined to a comparatively few species, chiefly the Bloodwood group, of which *E. corymbosa* may be regarded as typical, and is restricted to the young leaves. It also occurs on the young foliage of *E. maculata.* It is instructive to note that this feature is to be found chiefly on those Eucalypts whose leaves have the lateral veins arranged almost at right angles to the midrib. The character is also common on the young leaves of *Angophora lanceolata* and *A. intermedia*, which have a similar venation, thus showing some of the affinities between these two genera to which reference has been made by various writers. The device does not appear to have been adopted as a protection against cold, as it is rare if not quite absent at altitudes exceeding 3,000 feet in latitudes south of 32°, and it probably originated as one of the earliest forms of protection against hot or droughty conditions.

Glaucescence.—The clothing of the leaves with a glaucous powdery wax is often resorted to by the Eucalypts, and especially by the juvenile foliage, but in many instances this method of protection is adopted by the mature foliage as well, and under different conditions of climate, from that of the hot and dry Interior to that of the cool Mountain Region, and also with varying degrees of intensity according to the age of the leaves. This covering is largely met with in the cool climate, where it may be seen not only on the leaves and buds, but also on the branchlets, and in

[1] Crit. Revision of the Genus Eucalyptus, Part VIII.

some cases on the smooth-barked boles, as on *E. maculosa* and *rubida*. As already pointed out, (see Horizontal and vertical leaves) it is the method commonly availed of by those species whose leaves are sessile and orbicular to ovate;[1] and it appears to be a device adopted as a protection against evaporation which may be caused either by the heat of the dry lowlands, or by the winds and intensity of light in a clear atmosphere on the highlands.

Thick epidermis.—The thickening of the epidermis has already been referred to under "Thick and Thin Leaves."

Leaf Venation.

A study of the venation of a series of Eucalyptus leaves discloses the fact that the lateral veins are arranged at all possible angles with the midrib between the limits of about 10 to 80 degrees. Attention was first drawn to the botanical and chemical agreement of these venations in a paper read before this Society by Messrs. Baker and Smith in 1901. For convenience of reference, the venation in its relation to the midrib, may be divided into three classes, viz.:—transverse or right angled, oblique or diagonal, and parallel, although none of the veins form quite so much as a right angle with the midrib, nor are any strictly parallel therewith, and the oblique venation may be regarded as that where the lateral veins have a range of about 25 to 65 degress with the midrib.

In the transverse venation the lateral veins are straight, nearly parallel to each other and close together, while the intramarginal vein is close to the edge, and the midrib is thick.

In the oblique venation the lateral veins are further apart than in the last form, while the intramarginal vein is at some distance from the edge.

---

[1] H. Deane, M.A., Proc. Linn. Soc. N.S. Wales, Vol. xxv, p. 471, (1900).

In the parallel venation the lateral veins are well apart and sometimes show a system of looping, the intramarginal vein being well removed from the edge, and the midrib is thin.

Seeing the very great divergence which often exists between the seedling and adult leaves of the same tree, and also in the venation of the adult foliage of many species, it seems reasonable to suppose that the various ultimate types of venation have been developed in response to some influence or dominating condition, and if the distribution of these various types can be shown, some data should thereby be furnished that would assist in deciding what that particular regulating influence may have been.

Transverse venation.—Upon investigating the distribution of those Eucalypts which have the transverse venation, it is found that they form a very small proportion of the Eucalypts of South Eastern Australia, and are commonest in the Coastal Area, next in the Interior, and on the Western Slopes, and last in the Mountain Region, In the last named division, Eucalypts having this class of venation appear to be quite absent above an altitude of 3,000 feet, while one species, *E. trachyphloia*, occurs on the northern part of the Western Slopes, and another *E. terminalis* in the northern portion of the Interior. The venation of *E. tessellaris*, which occurs in the north-eastern portion of the Interior, is rather more oblique than transverse, and shows a sort of transit stage. It will be seen therefore that the Eucalypts with the transverse venation avoid the cold parts, and it is significant that they are absent from Tasmania, and almost so from Victoria, three species, *E. corymbosa*, *botryoides* and *maculata* occurring sparsely near the coast in the extreme north-east corner of that State. Further, there are only about a dozen species of this class which occur in South Eastern Australia though several are found connecting round through North to West Australia.

Judging by its wide distribution, and considering that this type of venation is practically identical with that of the genus *Angophora*, and avoids the cold, the assumption seems warranted that it belongs to the earliest form of Eucalyptus leaf, and also was developed in a warm climate in Northern Australia.[1]

Oblique venation.—A study of the oblique venation, or that which is intermediate between the approximately right angled and parallel venations, and of which *E. globulns* may be regarded as a type, reveals the fact that the bulk of the Eucalypts fall within this class. It is found that they occur in the dry Interior and also well up on the Mountain Region to elevations in a few cases of 5,000 feet. This form is most strongly represented in the Coastal Area, but that is largely because species and individuals are more numerous in that division. It is also the dominant form on the Western Slopes and in the Interior, in fact, except for the two species with transverse venation mentioned as occurring in those divisions, practically all other species there belong to the oblique venation series. It is fairly common in the Mountain Region between the altitudes of 2,000 and 4,000 feet, but becomes less plentiful above that elevation, and practically ceases just above 5,000 feet.

Considering the prevalence of this type of leaf all over Australia, it seems a correct assumption that it is fairly ancient, and was evolved from the transverse venation as a form better suited to make progress amidst the surroundings in which it was placed.

Parallel venation.—The type of leaf referred to as having parallel venation, or having the lateral veins arranged at an angle of less than about 25 degrees with the midrib, belongs chiefly to the Mountain Region, and secondly to

[1] "The Tertiary Flora of Australia," by H. Deane, M.A., Proc. Linn. Soc. N.S. Wales, Vol. xxv, p. 474, (1900).

the Coastal Area; and so far as New South Wales is concerned, is practically confined to those two divisions, the form being absent from the Western Slopes and the Interior. *E. coriacea* and *stellulata* are very pronounced examples of this class of venation.

A study of the distribution of this type of leaf in New South Wales, Victoria, and Tasmania, leads to the conclusion that it has been evolved largely if not wholly in response to cool and moist conditions, and it is of interest to note that the Eucalypt which ascends higher than any other in Australia, viz.:—*E. coriacea*, and which reaches an altitude of 6,500 feet, is one of the most typical of the parallel veined forms in the genus. Everything seems to point to the conclusion that the parallel veined leaf is the newest type of Eucalyptus leaf in existence, that it was developed in the south as an offshoot from the oblique venation, and after the Kosciusko uplift, migrated north along the resultant Main Divide throughout the entire length of New South Wales.

Geological formations selected by Eucalypts with various leaf venations.—Species having the various types of leaf venation appear to exercise some preference for different classes of geological formations. Those having the transverse venation generally select the acid rocks which are composed of upwards of 70% silica, much of which is in a free state. Species with the oblique venation are more typical of the basic rocks and soils, although by no means confined to that formation, some even growing on highly siliceous rocks. The trees with the parallel veins, such as *E. dives*, occupy chiefly the fairly siliceous formations or those containing between 60 and 70% silica, but some of them grow on basic formations, while others are on highly siliceous.

Fossil Leaves.

Of the fossil leaves which have been identified as Eucalypts in Miocene deposits in South Eastern Australia,

some are considered to possibly belong to other genera, but those recorded as Eucalypts are distributed somewhat as follows:—Those showing the transverse venation have been recorded from Oxley near Brisbane[1] in latitude $27\frac{1}{2}^\circ$, to Tasmania, and those with the oblique venation, from northern New South Wales to southern Victoria, though one or two of the Brisbane specimens show the beginning of the latter venation. A typical form of the oblique venation, *E. Pluti*, McCoy, has been found near Daylesford in Victoria in Miocene beds.

Mr. H. Deane has described what he regards as probably a Eucalyptus fossil, from a specimen discovered at Mornington, towards the extreme south of Victoria, under the name of *E. prœcoriacea.*[2] It has the parallel venation of the living *E. coriacea*, but also much resembles a phyllodineous *Acacia* or a *Hakea* as suggested by Mr. Deane. The same author has also described several species from the fossil flora of Berwick in about latitude 38°, but these belong chiefly to the section which has leaves with the early oblique venation, the lateral veins being usually arranged in these specimens at angles of from 40 to 65° or rarely 70° with the midrib. The Mornington and Berwick beds are doubtfully referred to the Eocene period.[3]

Mr. F. Chapman, A.L.S., in writing of some fossils of probably Janjukian or Miocene age, from Wannon Falls, Redruth, Western Victoria, says "Several fragments of long, ovate, pointed leaves, can without doubt be referred to the genus Eucalyptus. Their venation differs from those of the fossil species described by McCoy and Ettingshausen, in having remarkably long and sub-parallel veins; and very closely agree with the leaves of *E. amygdalina.*"[4]

---

[1] Baron von Ettingshausen, Denks. K. Akad. Wissen. Wien., Math.-Naturw. Cl. LXII, p. 48, (1895).
[2] Records Geol. Sur., Victoria, 1902, p. 20.
[3] A. E. Kitson, F.G.S., Rec. Geol. Sur., Victoria, 1902, p. 52.
[4] Proc. Roy. Soc. Victoria, 1910, p. 25.

If the extreme or parallel type of venation had been evolved in Eocene or early Miocene time, then it would seem not unlk ely that the genus originated as far back as towards the close of the Cretaceous, though its occurrence in Europe in Cretaceous or Tertiary time seems most improbable as already pointed out by Mr. Deane.[1]

Mr. R. M. Johnston has described two species of Eucalyptus from fossil leaves found in Tasmania, one, *E. Kayseri* from Mount Bischoff, and the other, *E. Milligani* probably from Macquarie Harbour.[2] From the drawings, these both belong to the transverse venation type, and this implies that Eucalypts, having leaves with this class of venation had extended south to latitude 42° in Eocene or Miocene time, or about 4° beyond where living examples of this type are found to day. In his Presidential Address to the Linnean Society Mr. Deane referred to this phase of distribution, owing to the warmer early Tertiary climate, and said:—"Taking into consideration the difference between the Eocene and Miocene climate and that of the present period, we might expect to find existing types a few degrees further south in the fossil state."[3]

Mr. Chapman has also kindly shown me a Tertiary fossil leaf with the oblique venation, probably a Eucalypt, from near Burnie in Tasmania.

The leaves described by Ettingshausen as Eucalypts, from Miocene beds at Emmaville (Vegetable Creek) in latitude $29\frac{1}{2}$°, include those with both the transverse and oblique venations, the former predominating.[4]

---

[1] Proc. Linn. Soc. N. S. Wales, Vol. xxv, p. 463, (1900). Also, "Flora of the Amboy Clays," by J. S. Newberry, Monographs U.S. Geol. Survey, Vol. xxvi, p. 46, (1895).

[2] "Geology of Tasmania," by Robt. M. Johnston, F.L.S., (1888).

[3] Proc. Linn. Soc. N.S. Wales, Vol. xxi, p. 832, (1896).

[4] Memoirs of the Geological Survey of N.S. Wales, Palæontology No. 2, Tertiary Flora of Australia by Dr. Constantin, Baron von Ettingshausen, (1888.)

The somewhat meagre fossil evidence available rather supports the idea that the transverse venation belongs to the earliest form of Eucalyptus leaf, while it also goes to show that even the extreme or parallel type of venation flourished in the south as far back at least as the Miocene period. After the Kosciusko uplift, and perhaps assisted by the glacial period in Pleistocene time, this latter type was enabled to invade New South Wales from south to north by travelling along the Main Divide.

Inflorescence.

Anther.—The only portion of the flower which I propose to discuss is the anther, and this is the most important part of the inflorescence from a diagnostic point of view. Bentham, in that classical work, the Flora Australiensis, was the first to group the Eucalypts according to the anthers. He arranged them into five sections which Baron von Mueller reduced to three on finding difficulties in maintaining the larger number separately.[1] My remarks will be confined to the three groups viz.:—

Parallelantheræ.—The cells and consequently the longitudinal slits parallel.

Porantheræ.—The anthers small and opening in pores.

Renantheræ.—The anthers fairly large, the cells divergent at the base, and confluent at the summit.

In a large genus like Eucalyptus it is not surprising to find that there is a gradation of characters from one species to another, and this varietal tendency applies in a marked degree to the anthers. But on studying the distribution of the three general types of anther, it becomes evident that to some extent such distribution is regulated by climatic influence, or that a certain form of anther is often better represented in one class of climate than another.

[1] For remarks concerning variation of anthers, see "A Critical Revision of the Genus Eucalyptus," by J. H. Maiden, F.L.S., Part I, p. 11.

Parallelantheræ.—The parallel anther is by far the commonest type of anther in the genus, being found all over Australia, and is the form which belongs to the closely allied genus *Angophora.* It has been noticed, however, that this form becomes less common above an altitude of 4,000 feet. If we consider that all the present forms of anther have been evolved from one original type, then it would seem that the type known as parallelantheræ bears the nearest resemblance to the original. This hypothesis is supported by the wide distribution of this particular form, and the fact that it passes by gradual stages to the porantheræ on the one hand and the renantheræ on the other.

In associating anthers with leaves it is seen that the parallel anther and the leaf with oblique venation as well as the transverse venation, usually go together, but it is not the form of anther which is associated with the parallel venation.

Porantheræ.—The porantheræ section is largely confined to the inland portions of Eastern Australia, and compared with the last mentioned type, is a comparatively small section, being chiefly found amongst the Box-trees, Ironbarks, and some Mallees. For the purpose of this address it is made to include the form known as the truncate anther. In New South Wales the porantheræ has its greatest number of representatives in the Interior and Western Slopes, and occurs to a less extent in the Coastal Area. The one condition that it distinctly avoids is the cold, and it is absent from the Mountain Region above elevations of about 3,000 feet, south of latitude 31°, and also from Tasmania, one of the trees with this type of anther best able to face the cold being *E. melliodora.* The form of leaf-venation associated with this anther is the oblique venation.

It is pointed out that the Eucalypts which belong to the porantheræ section rather favour the basic than the siliceous formations, and it seems not improbable that an extended study of that phase of development which results from response to certain plant food, may largely help to elucidate some of the mysteries of evolution in the genus.

Renantheræ.—Turning now to the renantheræ, we find that it is practically confined to South Eastern Australia, and is the principal form occurring in the higher Mountain Region, and also that nearly all those Eucalypts having leaves with the parallel venation possess the kidney-shaped anther. Next to the mountains it is most common in the Coastal Area, but on the drier Western Slopes is rare indeed, while in the still drier Interior of New South Wales this form of anther does not occur at all.

Considering this general distribution of the last named two types of anther, there seem reasonable grounds for assuming that one necessary condition for the development of the former is warmth, while the latter is largely the result of moist and cool surroundings.

There are anomalous members of the section renantheræ, which in an evolving genus is not a matter for surprise, examples being found in such species as *E. Smithii* and *microcorys.*

When writing of *E. pauciflora (coriacea)* in the Eucalyptographia, Baron von Mueller refers to the relationship which exists between the renantheræ type of anther and the leaves with parallel venation.

Essential Oils.

In their "Research on the Eucalypts," Messrs Baker and Smith record that three of the important constituents of the essential oils obtained from the leaves are:—pinene, eucalyptol (cineol) and phellandrene. At least one of these constituents has been obtained from almost every Eucalypt

they have examined, and in some cases all three have been present. Out of 110 species examined, eucalyptol is given as the principal constituent in 50, pinene in 31, and phellandrene in 26 species. Eucalyptol occurs in 95 of the species examined, pinene in 95, and phellandrene in 36. It will be convenient to refer to these oils as pinene, eucalyptol, or phellandrene oils, according to which constituent predominates.

The above mentioned authors have already pointed out that broadly speaking the leaves having the transverse venation contain a large proportion of pinene, while the oblique and the parallel venation respectively indicate the presence of eucalyptol and phellandrene in predominating proportions.

Pinene.—In considering the distribution in New South Wales, of the typical pinene oil-yielding species, such as *E. corymbosa* and *saligna* etc., it is found that the bulk of them occur in the Coastal Area. The remainder are distributed throughout the lower Mountain Region and the western parts of this State. They are practically absent from altitudes exceeding 4,000 feet in latitudes south of 32°, an exception being found in *E. rubida*, which flourishes at elevations up to 5,000 feet. This species, however, is not regarded as one of the typical pinene oil trees, the lateral veins in its leaves coming within the oblique venation, and its total yield of oil when tested was phenomenally low. Pinene therefore appears to be a constituent which, in the Eucalypts, has been developed amongst warm rather than cold surroundings.

In the light of our present knowledge it seems undoubted that the Eucalypts have been either evolved from the Angophoras, or perhaps more probably that both genera have come from some common ancestor now extinct, and as pinene occurs in the Angophoras, and is the principal

constituent in what are regarded as the earliest forms of Eucalypts now remaining, that constituent is likely to occur in some varying quantity throughout the slowly evolving genus.

In seeking for some relationship between essential oils and geological formations, it is found that those Eucalypts typical of the class which produce pinene oils, prefer siliceous to basic formations, and select those of the former where much of the silica is in a free state.

Eucalyptol.—The species which contain a large proportion of eucalyptol (cineol), appear to comprise the bulk of the genus, and so far as New South Wales is concerned, occur most in the Coastal Area and Interior as well as lower Mountain Region, and are found least in the coldest parts, *E. amygdalina* being an exception. This appears to be the dominant constituent of the genus at the present day, and as it appears to mark a transition from pinene of the warm, to phellandrene of the cold climate, it should be expected to diminish in quantity, even in the same species, as an ascent is made into the colder altitudes. Eucalyptol-yielding species usually occur on geological formations varying from basic to fairly acid, and even occasionally on very siliceous rocks, but of the three oil-yielding groups this is perhaps the most typical of the basic formation and may be found on the black soils of the Interior.

Phellandrene.—The home of this constituent in its greatest volume is in the Mountain Region, and in a reducing quantity it occurs in the Coastal Area, Western Slopes and the Interior, being rare in the last named division. In none of these schemes of distribution is any particular character or quality found to be confined precisely within any exact limits, nor is such a condition of grouping to be expected in an evolving genus, but in outlining their distribution, characters are regarded as typical

of the areas in which they predominate. A study of the distribution of phellandrene, as revealed by Messrs. Baker and Smith's researches, points undoubtedly to the conclusion that this constituent has been chiefly produced under conditions of cold and moisture, being the principal ingredient in the oils of such cold loving species as *E. dives*, *vitrea*, *Andrewsi*, *coriacea* and *stellulata*, and notwithstanding that it is recorded as occurring in two species from the Interior, which are totally different from mountain species, viz., in *E. microtheca* and *melanophloia*, its home is in the Mountain Region and southern Coastal Areas of South Eastern Australia.

Phellandrene-yielding trees occur on formations from basic to acid, but usually prefer those with upwards of 60% silica, and generally avoid alkaline soils.

Summary.

From a study of the physiographic, geological, and climatic conditions of South Eastern Australia the following general conclusions have been arrived at in regard to the development and distribution of the genus Eucalyptus.

In early Tertiary time the country had a fairly level surface and a low elevation, with a mild to warm climate, and the flora for two or three hundred miles inland from the east coast was of a more uniform character than at present. A succession of slight upheavals from the early Miocene period onwards, and which culminated in the Kosciusko period, created climatic conditions which produced a differentiation of floras on the eastern, central, and western sides of the uplifted area. By investigating the distribution of the Eucalypts, particularly in regard to certain characters of the anthers, leaves, and essential oils, some uniformity is found, within certain limits, in the development of these various characters. Considering, however, the great length of time the genus has been

developing, possibly ever since late Cretaceous time, it is to be expected that a considerable overlapping of evolutionary characters exists, and such being found to be the case, this tends to render the forming of definite conclusions more difficult.

The available evidence points to the conclusion that the Eucalypts either invaded, or probably originated in the northern or warm, rather than the southern or cold portion of Australia. The anthers belonged to the section known as parallelantheræ, the leaves had the transverse venation, and the chief constituent of the essential oils was pinene. The type of Eucalypt containing the transverse venation is absent from Tasmania, and in latitudes south of about 35° is confined to a comparatively narrow coastal strip in New South Wales and Victoria. As the genus evolved, its characters continued to be modified in response to its surroundings, largely it would seem through its invasion of colder latitudes, and later by its ascent to greater elevations produced by earth movements along Eastern Australia and probably from other causes not yet understood, amongst which are likely to be its selection of different plant foods owing to the class of geological formation which supported its growth, and the amount of moisture present. A transition began to appear from the parallelantheræ towards the porantheræ, a somewhat small section which avoids the cold regions, and also in an opposite manner towards the renantheræ, a section which shuns hot and dry conditions, but favours the cold and moist. The transverse venation was also largely superseded by the oblique or diagonal venation, and eucalyptol (cineol) became an important constituent of the essential oil in the leaves.

At the present day the home of the typical renantheræ is largely in the cool and moist regions, and with it may be found the majority of those species whose leaves have

the parallel venation, and the bulk of those whose leaves yield the greatest quantities of phellandrene oil.

It is freely conceded that the typical characters referred to are not absolutely the product of any one condition, nor would such a result be expected when the great range and the variation of this large genus are considered, and while the varying geological formations with their diverse amounts of silica and alkalies have been amongst the most important factors in regulating the development of the Eucalypts, the dominating influence which is broadly responsible for the regulation of their distribution over the whole continent is that of climate.

PRODUCTS OF THE ACTION OF CONCENTRATED SULPHURIC ACID ON IRON.

By C. W. R. POWELL,
Science Research Scholar, University of Sydney.
(Communicated by Professor C. E. Fawsitt, D.Sc., Ph.D.)

[*Read before the Royal Society of N. S. Wales, June 4, 1913.*]

THE action of sulphuric acid on metals generally seems to depend largely on the temperature at which the reaction takes place and upon the concentration of the acid. The reactions generally accepted are:—

(1) that dilute sulphuric acid, either hot or cold, acting on a metal produces hydrogen gas and sulphate of the metal according to the equation:—

$$M + H_2SO_4 = MSO_4 + H_2,$$

where M is any divalent metal, and—

(2) that concentrated sulphuric acid in the cold has very little action, but when heated produces sulphur dioxide gas, sulphate of the metal and water:—

$$M + 2H_2SO_4 = MSO_4 + SO_2 + 2H_2O.$$

Statements in connection with the action of concentrated sulphuric acid on metals in the cold are somewhat conflicting, but it would appear that the nature of the reaction, if any takes place, is very largely influenced by the metal employed. Baskerville[1] groups the reactions with copper into two classes.

(A) Primary.

1. $Cu + 2H_2SO_4 = CuSO_4 + SO_2 + 2H_2O,$

this reaction taking place in two stages:—

(*a*) $Cu + H_2SO_4 = CuSO_4 + 2H;$

(*b*) $2H + H_2SO_4 = SO_2 + 2H_2O.$

2. $5Cu + 4H_2SO_4 = Cu_2S + 3CuSO_4 + 4H_2O.$

[1] Jour. Amer. Chem. Soc. XVII, p. 904, (1895).

(B) Secondary.

1. $Cu_2S + 2H_2SO_4 = CuS + CuSO_4 + SO_2 + 2H_2O$.

2. $CuS + 2H_2SO_4 = CuSO_4 + S + SO_2 + 2H_2O$.

He finds that the primary reactions predominate between 0° and 270° C. and that the gases evolved contain no hydrogen. Sluiter[1] has gone a little further and proved the presence of nascent hydrogen in the acid by reducing nitro-benzene to aniline. Pickering[2] also classified the reaction as above and in addition pointed out that the formation of nascent hydrogen is not necessitated by the production of cuprous sulphide according to the second primary equation. He states that copper is attacked at 19° C. (and probably lower), but that with the exception of a few minute bubbles no gas is evolved until about 130°.

The action of concentrated sulphuric acid on mercury somewhat resembles that on copper, sulphur dioxide gas and mercury sulphate being formed with no trace of hydrogen at 150° and 200° C. However in this case it is considered that the acid is directly reduced by the metal without the intermediate formation of nascent hydrogen.[3]

Zinc and iron react similarly to each other, but differ from copper and mercury in producing hydrogen with the concentrated acid.[4] With regard to the evolution of sulphur dioxide gas, Thomsen says that the formation of the gas is hindered by the tendency of the molecules to retain their original configuration, and it is only when the opposition to any change of the *status quo* is removed by raising the temperature and concentration that the reaction proceeds. Ditte[5] has carried out very complete researches on the

---

[1] Jour. Soc. Chem. Ind., 1906, p. 318, also Chem. Weekblad, III, pp. 63 – 66, (1906).

[2] Chem. Soc. Trans., 1878, p. 113.

[3] Baskerville and Miller, Jour. Amer. Chem. Soc., XIX, p. 873.

[4] Thomsen, Thermochemistry, also Ditte, Ann. Ch. Pharm. XIX, p. 68, (1890). [5] Ditte, *loc. cit.*

action of a large number of metals on sulphuric acid and has found that the concentrated acid in the cold acts very slowly on iron, the rate of gas evolution being still slow at 130°, only commencing to increase appreciably at 150°, when the gas consists of a mixture of hydrogen and sulphur dioxide. When the dilution of the acid reaches about 1:3, hydrogen alone is evolved whatever the temperature. At all dilutions with iron he detected sulphuretted hydrogen together with sulphide of iron, the latter accounting for the darkening of the acid. With concentrated acid the sulphuretted hydrogen was decomposed with precipitation of sulphur. Thomsen pointed out the formation of H_2S in connection with zinc, stating that if the dilute acid was evaporated, an intermediate reaction took place when a certain concentration was reached according to the equation,

$$4\,Zn + 5\,H_2SO_4Aq = 4\,ZnSO_4Aq + H_2S + 4\,H_2O.$$

It is the custom in commerce to store sulphuric acid in iron drums and in iron tanks, and as the present view is that the concentrated acid is practically without action on iron in the cold, the practice is generally considered to be quite safe. With regard to the manufacture of Nordhausen sulphuric acid, Roscoe and Schorlemmer[1] mention that certain absorbers are used "containing concentrated sulphuric acid, being made of wrought iron which is not attacked by acid of this strength (97 - 98%), whereas cast iron although not corroded rapidly cracks under these conditions."

The present investigation was undertaken specially in connection with iron, and the author finds that this metal has a definite action on concentrated sulphuric acid in the cold, and that the products of the reaction are mainly ferrous sulphate and hydrogen. There is also a small quantity of sulphur dioxide gas formed.

[1] Treatise on Chemistry, Vol. I, see also Lunge, Sulphuric Acid and Alkali, Vol. I, p. 39.

Materials Used.

In the laboratory experiments steel wire was used and Elliott Bros.' "Chemically Pure" sulphuric acid, density 1·842. The steel wire was polished with emery cloth before use and immersed in the acid with as little delay as possible, so as to avoid the influence of impurities, such as rust, coming into the reaction.

In the first experiments conducted it was noticed, after the sulphuric acid had been acting on the steel for some months, that the flask contained a large amount of a whitish precipitate which was present in sufficient quantity to obscure the steel. This was at first supposed to be a complex compound of iron, sulphur and oxygen, but subsequent analysis proved it to be ferrous sulphate, in all probability anhydrous, although it is just possible that it consisted of the monohydrated salt.

Methods of Analysis.

The sediment from the flask was poured into a beaker containing alcohol, and after being well mixed was filtered through a Soxhlet filter paper. The paper was then placed in a Soxhlet apparatus as used for fat extraction, and washed with boiling alcohol. The washing was continued for two days when practically the whole of the sulphuric acid was removed. This method of purification was adopted after trying others, and alcohol was found to be much preferable to any other solvent as a washing fluid. The acid-free sediment was dried in a water bath at 100° C. and analysed gravimetrically with the following results:

Fe	...	32·8%
SO_4	...	57·7%
Adding up to	...	90·5

If the formula be taken as $FeSO_4 + H_2O$, that is monohydrated ferrous sulphate, the total then adds up to 101·0, which in this case is within the limits of experimental

error. Some crystals of $FeSO_4 + 7\,H_2O$ were then treated with concentrated sulphuric acid and washed with alcohol in a similar manner, to see if one molecule of water was retained as found above. The analysis showed this to be the case.

This was previously noticed by Scott[1] who worked on mixed sulphates of copper and iron. He found that $FeSO_4 + H_2O$ is easily prepared in the following manner:—a saturated solution of the salt (hydrated, $7\,H_2O$) is prepared in the cold, and an equal volume of concentrated sulphuric acid added. A precipitate is obtained and washed two or three times with H_2SO_4 diluted with its own volume of water, then with absolute alcohol, then with a mixture of absolute alcohol and dry ether, and finally with dry ether, and dried over concentrated H_2SO_4 in an evacuated desiccator. Roscoe and Schorlemmer state that ferrous sulphate is insoluble in concentrated sulphuric acid and absolute alcohol, but dissolves slightly in dilute alcohol. Hence, sulphuric acid and alcohol precipitate solutions of sulphate, the precipitate containing varying quantities of water of crystallisation according to the amount of precipitant and concentration of the solution.

This previous work is in accordance with the author's analysis of the powder obtained from $FeSO_4 + 7\,H_2O$ by treatment with sulphuric acid and alcohol, and a comparison between this analysis and that of the sediment obtained directly from the iron by action of H_2SO_4 indicates the close relation between the two.

	Sediment from Experiment.	Prepared from $FeSO_4 + 7\,H_2O$.	Calculated for $FeSO_4 + H_2O$.
Fe	32·8	32·6	32·88
SO_4	57·7	56·4	56·51

The conclusion drawn was that anhydrous ferrous sulphate was formed by action of concentrated sulphuric acid

[1] Jour. Chem. Soc., 1897, p. 564.

on steel wire and converted into the monohydrated salt by the method of purification adopted, a possible alternative view being that there was sufficient water in the flask to form $FeSO_4 + H_2O$ initially, since in addition to the $2-3\%$ of water found in the acid, a further amount was being continuously formed in the generation of sulphur dioxide gas according to the equation :—

$$Fe + 2\,H_2SO_4 = FeSO_4 + SO_2 + 2\,H_2O,$$

two molecules of water being formed for every one of ferrous sulphate. However this will be again discussed when the respective amounts of SO_2 and hydrogen have been recorded.

Method of Gas Analysis.

The gas evolved was analysed in Hempel's apparatus, using a modified Winkler gas burette. After observing the initial volume and temperature the mixture of gases was passed into a Hempel gas pipette, containing a solution of potassium hydrate, when all the sulphur dioxide was absorbed (as well as any other soluble gases which may have been present in very small quantities). The diminution in volume represented the volume of SO_2 originally present after allowing for the vapour tension of the KOH solution, since the gases at start were dry owing to the dehydrating action of the sulphuric acid used to obtain them. The remaining gas was then passed into a gas pipette filled with a solution of alkaline pyrogallol prepared by mixing together—directly in the gas pipette—5 grams of pyrogallol dissolved in 15 c.cms. of water and 120 grams of KOH dissolved in 80 c.cms. of water. The gas absorbed by this solution was considered to be atmospheric oxygen, and a corresponding amount of nitrogen calculated on the basis that air contains 21% of oxygen by volume. About 16 c.cms. of the oxygen-free gas were then passed into a pipette and mixed with an excess of air, exploded in an explosion pipette and the contraction in volume observed.

In the first determinations the gases after explosion and measurement were again passed into the KOH pipette to see if any gases soluble therein (such as CO_2) had been formed by the explosion. In no case was a contraction in volume here obtained, hence it was concluded that no appreciable quantity of methane or any other gas insoluble in KOH itself, and which would give CO_2 on explosion, was originally present in the gas. After observing the contraction in a duplicate explosion, the excess of oxygen was absorbed in alkaline pyrogallol as a check on the subsequent calculations. Two thirds of the diminution in volume due to the explosion represented the volume of hydrogen in the volume of gas diluted with air. The detailed order of analysis was as follows :—

Original volume of gas	and temperature °C.
Volume after absorption in KOH	,,
Volume after absorption in Pyro.	,,
Any volume of remainder	,,
Volume after addition of air	,,
Volume after explosion	,,

In the following tables of analyses of gases evolved, sulphur dioxide and hydrogen are expressed as percentages of gas evolved, *i.e.*, SO_2 and hydrogen add up to 100. This affords an easier comparison than if the amount of air determined was included in the tables, since for different experiments the actual analyses show varying amounts of air. The air found in the gases is simply the air which was in the flask at start, and had been carried over along with the SO_2 and hydrogen into the measuring cylinder, and was estimated as stated in order to make sure that all the constituents of the gaseous mixture were being ascertained. As the gases were analysed at frequent intervals in order to see if the composition changed with the lapse of time, in most cases only 25 c. cms. were available for analysis.

Three experiments were carried out with the steel mentioned, and the analyses of gases evolved at 30° C. show approximately the same ratio of SO_2 to hydrogen.

Experiment I.

Time in days.	Temperature °C.	SO_2	H	
10	30	5·5	94·5	100·0
40	30	4·9	95·1	100·0

The first column in the table expresses the time the reaction has been proceeding, and the second records the temperature at which the sulphuric acid was maintained. In Experiment I, 19·405 grams iron were immersed in about 60·0 c. cms. of concentrated H_2SO_4.

Experiment II.

Time in days.	Temperature °C.	SO_2	H	
18	30	2·0	98·0	100·0
32	30	6·3	93·7	100·0
54	30	4·9	95·1	100·0
3	35	7·5	92·5	100·0
6	35	8·0	92·0	100·0
8	35	6·8	93·2	100·0
12	40	10·5	89·5	100·0

In this table column one expresses time for each temperature, starting from zero again every time the temperature was changed. 17·906 grams iron were in this experiment immersed in about 60·0 c. cms. of concentrated sulphuric acid.

Experiment III.

Time in days.	Temperature °C.	SO_2	H	
8	25	3·2	96·8	100·0
19	30	7·3	92·7	100·0
25	30	7·7	92·3	100·0

In Experiment III, 20·97 grams of iron were immersed in about 70 c. cms. of concentrated sulphuric acid.

Analysis of Gas evolved from a Mild Steel and Commercial Sulphuric Acid.

This mild steel contained 0·5% of nickel, and the commercial acid contained 95% H_2SO_4—being somewhat less pure than that used in the above three experiments. The reaction was allowed to proceed for some time before the initial analysis was made, and in the following table subsequent analyses are timed from the initial analysis. The amount of air in the gases was determined as before, and sulphur dioxide and hydrogen are again expressed as percentages of total gases evolved.

Gases evolved, using Mild Steel.

Time in days.	SO_2	H	
–	2·1	97·9	100·0
4	1·2	98·8	100·0
11	·8	99·2	100·0
15	1·0	99·0	100·0
39	·8	99·2	100·0

This series of experiments was carried out at atmospheric temperature, which for the 39 days over which the analyses extended was generally 25 – 27° C. In the above table the ratio of SO_2 to hydrogen is somewhat smaller than that obtained in the experiments with steel wire. But the main facts are still the same, namely, that concentrated sulphuric acid has a definite action on iron in the cold (25 – 30° C.), and in no case was hydrogen gas liberated without sulphur dioxide gas being formed at the same time.

From this it would seem to be the case that two actions are proceeding simultaneously, one producing hydrogen and ferrous sulphate, and the other sulphur dioxide, ferrous sulphate and water according to the equations:—

1. $Fe + H_2SO_4 = FeSO_4 + H_2$.
2. $Fe + 2\,H_2SO_4 = FeSO_4 + SO_2 + 2\,H_2O$.

The gas analyses show that the greater part of the reaction is taking place according to Equation 1, on an average 93% of hydrogen being liberated to 7% sulphur dioxide (at 30° C.). Hence it might be concluded that this is the initial reaction, and that the nascent hydrogen is only able to reduce a small amount of the sulphuric acid at the temperature of the experiment. This theory would be substantiated by analysing the gases evolved at higher temperatures, and the author is at present carrying the investigation further with this end in view.

Some preliminary experiments have already been conducted, and a few of the results are included to indicate the course of the reaction above 100° C. The percentage of SO_2 rapidly increases, until at 180° C. the amount of hydrogen, if any is present at all, becomes too small to be detected by the ordinary method of analysis.

Temperature °C.	SO_2	H	
150	47	53	100·0
165	48	52	100·0
180	100	...	100·0
200	100	...	100·0

Warner[1] has stated that sulphuric acid is not reduced by hydrogen unless nascent below 160° C., and from the above table it will be seen that a very marked change in the reaction occurs between 165 – 180° C.

However, it may be the case that the sulphur dioxide is produced by a direct reduction of the acid by the iron, as has been shown to be the case with mercury[2]—although with copper as has already been referred to, the intermediate formation of nascent hydrogen has been definitely proved.[3] The rate of the reaction and the influence of impurities in both the H_2SO_4 and the iron upon the reaction are also at present being studied.

[1] Chem. News, XVIII, 13, p. 1873. [2] *Loc. cit.* [3] *Loc. cit.*

In view of the results of the gas analyses, it may be stated that the ferrous sulphate formed must for the most part consist of the anhydrous salt, as the amount of water formed according to Equation 2, would not be nearly sufficient to convert the whole of the sulphate into the monohydrated salt. Thus, considering that Equation 1 is proceeding nine times as fast as Equation 2, there would be ten molecules of $FeSO_4$ formed to two of H_2O, so that at the most only one-fifth of the sulphate formed could be converted into $FeSO_4 + H_2O$.

It has been suggested by Van Deventer,[1] in connection with the action of concentrated sulphuric acid on iron, that the initial action consists rather in the formation of oxide, sulphur dioxide and water than in the formation of sulphate and hydrogen. He also states that no direct proof of the formation of hydrogen has yet been found. The author's results are contrary to this theory, and no oxide of iron was found in the analysis of the compound formed.

This investigation was carried out in the Chemical Department of the University of Sydney, and I wish to express my thanks to Professor C. E. Fawsitt, D.Sc., Ph.D., for his advice throughout the work.

---

[1] Chem. Weekblad., II, pp. 137 – 140.

NOTE ON THE OCCURRENCE OF COCCIDIOSIS IN HOUSE SPARROWS AND IN BOVINES IN N.S.W.

By J. BURTON CLELAND, M.D., Ch.M.
Principal Microbiologist to the Government of New South Wales.

[*Read before the Royal Society of N. S. Wales, June 4, 1913.*]

I. COCCIDIOSIS IN THE COMMON SPARROW, *Passer domesticus.*

Through the courtesy of Mr. H. W. Potts of the Hawkesbury Agricultural College, we have had an opportunity of examining a number of sparrows which he has kindly forwarded to us. In many of these, numerous oocysts of the coccidial parasite, *Isospora lacazei*, Labbe, were found. Some of these were rounded, and measured 21·5μ to 27·5μ, others were more oblong, varying from 23·5μ to 27·5μ by 17·5μ to 25·5μ. After placing the intestinal contents containing the oocysts into a weak solution of potassium bichromate, the formation of two sporoblasts could be followed out. The mature sporoblasts measured from 16·5μ to 17·5μ by 9·5μ to 11μ. According to Doflein's "Lehrbuch der Protozoenkunde," this species is a parasite of the gut of very many passerine birds, especially the common sparrow, larks, and goldfinches; its occurrence, therefore, in New South Wales amongst the domestic sparrows is only to be expected. Attempts were made to convey infection to domestic chickens, but these failed. It is therefore highly unlikely that this coccidial parasite of sparrows can infect poultry and thus be a source of danger to this industry in Australia; on the other hand the parasite may possibly be advantageous by causing a certain amount of fatality in young sparrows, and thus diminishing slightly the numbers of this pest. So far the allied parasite *Eimeria*

avium has not been recorded in fowls in New South Wales, although material from cases of supposed "Black-head" in turkeys has been examined by us, in which they were probably present, but the identification could not be confirmed.

II. The Occurrence of Coccidiosis in Australian Cattle.

In August, 1912, in examining sections of the large intestine of an Ayrshire cow which had died near Lismore, a few coccidia were noticed embedded in the epithelium. Their numbers were few, and only several small groups were noticed. The stages present were mature oval thick-walled oocysts, and near them immature forms with many granules peripherally arranged. Intestinal coccidiosis in cattle, which is supposed to be due to the same parasite (*Eimeria stiedœ*) as occurs in rabbits, has been recorded from the Alps in Europe and from South Africa. In both places considerable mortality has followed. The symptoms consist chiefly of a blood-stained diarrhœa. In the present instance, the animal in which the parasites were found was one of several which died with hæmorrhagic lesions of the intestinal canal. In only this one were coccidia found, and in it they were few in number. Imperfect material had, however, been forwarded in some of the cases. The coccidia agreed in appearance and dimensions with similar stages of *Eimeria stiedœ* from rabbits in New South Wales. It is stated, however, that rabbits are not known to occur near the locality occupied by the cattle. It would seem either that the affected animal and others had contracted the infection from rabbits or that the intestinal coccidiosis had been imported from abroad with cattle, and that the infestation of fresh hosts from time to time had formed a reservoir for the preservation of the coccidia. Man is also recorded as an occasional host of *Eimeria stiedœ*.

NOTE ON THE GROWTH OF THE FLOWERING STEM OF *Xanthorrhœa hastilis*, R.Br.

By J. BURTON CLELAND, M.D., Ch.M.

[*Read before the Royal Society of N. S. Wales, June 4, 1913.*]

IN April, 1912, one of several specimens of grass-tree (*Xanthorrhœa hastilis*, R. Br.), which had been rescued from destruction when the ground, which is now my garden, was cleared for building, started sending up its flowering-stalk. This stem eventually reached a height of about eight feet with a diameter of about an inch. My attention was soon attracted by two features, the rapidity of growth and the inhibitory influence of direct sunlight. The former soon led me to take measurements with a foot rule, and the latter induced me to note the height both morning and evening. Appended are the daily measurements taken. The most rapid rate of growth, it will be noted, was between 6 p.m. on April 15 and 8 a.m. next morning, during which the height had increased by 4 inches. The preceding hours of daylight had only added $\frac{3}{4}$ in. and the succeeding ones $\frac{1}{4}$ in. The next night saw a further addition of 3 in., and the following day $1\frac{1}{2}$ in. The night of April 18 – 19 saw $3\frac{1}{2}$ ins., the preceding day having added $\frac{1}{2}$ in. only, and the succeeding one nothing. These are the most striking instances of rapid growth by night and slight growth by day, but throughout, if the weather were bright and sunny, the same tendency was manifest. On April 27, the influence of direct sunlight was strikingly displayed. At 8 a.m. the stem was straight, height 4 feet 10 inches. On my return at 1 p.m., I was dismayed to see, as I thought, the stem dying away. It was bent over towards the sun, so that its upper half formed almost a complete semicircle.

The sun had been shining brightly upon it the whole morning. At 6 p.m., the stem had not only recovered its normal erect state but had begun to decline to the south. During this day, only $\frac{1}{4}$ in. had been added in height.

The features I have mentioned are, of course, well-known. Their striking degree in this instance and the fact that the subject is one of our native plants have induced me to bring them under notice.

	8 a.m.	6 p.m.
April 14—	1 ft. 10 in.	1 ft. 11 in.
,, 15—	2 ft. 1 in.	2 ft. $1\frac{3}{4}$ in.
,, 16—	2 ft. $5\frac{3}{4}$ in.	2 ft. 6 in.
,, 17—	2 ft. 9 in.	2 ft. $10\frac{1}{2}$ in.
,, 18—	3 ft. 1 in.	3 ft. $1\frac{1}{2}$ in.
,, 19—	3 ft. 5 in.	3 ft. 5 in.
,, 20—	3 ft. 7 in.	3 ft. $10\frac{1}{4}$ in.
,, 26—	...	4 ft. $8\frac{1}{2}$ in., bent to south.
,, 27—	4 ft. 10 in., straight.	4 ft. $10\frac{1}{4}$ in. (7 p.m.) bent to south.

At 1 p.m. on the 27th, the upper half of the stem was curved to the north in an almost perfect semicircle. The day was warm, bright, and sunny.

	8 a.m.	6 p.m.
,, 28—	4 ft. $11\frac{1}{2}$ in., slight turn to the south.	4 ft. $10\frac{3}{4}$ in., turned slightly to the north at 6 p.m. and at 8 p.m.

During most of the day turned to the south. In the afternoon, gradually reversed to the north.

	8 a.m.	6 p.m.
,, 29—	5 ft. $0\frac{1}{4}$ in., slight turn to the north.	5 ft. $0\frac{1}{4}$ in., straight. Wet day.
,, 30—	5 ft. 3 in., slight turn to the east. Wet day.	5 ft. $3\frac{1}{2}$ in., slight turn to the south-west.
May 1—	5 ft. $3\frac{3}{4}$ in. slight turn to the north-east. Fine cold day.	5 ft. $3\frac{3}{4}$ in., straight. Night was cold.
,, 2—	5 ft. $3\frac{3}{4}$ in., slight turn to the west.	5 ft. $4\frac{1}{2}$ in., slight turn to the west.

	8 a.m.	6 p.m.
May 3	5 ft. $5\frac{3}{4}$ in. (probably too high a reading), slight turn to the east. Fine day.	5 ft. $5\frac{1}{4}$ in., (measured twice), straight.
,, 4	5 ft. $5\frac{1}{2}$ in., slight turn to the west.	
,, 5	5 ft. 7 in., slight turn to the east. Wet day.	Straight.
,, 6	5 ft. $7\frac{1}{2}$ in., straight.	Straight.
,, 7	5 ft. 8 in., straight.	Straight.
,, 8	5 ft. $9\frac{1}{2}$ in., straight.	
,, 9	5 ft. $9\frac{3}{4}$ in., straight.	
,, 10	5 ft. 11 in., straight.	
,, 11	6 ft. 0 in., straight.	
,, 13	6 ft. 1 in., straight.	
,, 14	6 ft. $1\frac{3}{4}$ in., slight turn to north-west.	
,, 15	6 ft. 3 in.	
,, 16	6 ft. 4 in., slight turn to east.	
,, 17	6 ft. $4\frac{1}{4}$ in., straight.	
,, 18	6 ft. $5\frac{1}{2}$ in., nearly straight.	
,, 19	6 ft. $5\frac{3}{4}$ in.	
,, 20	6 ft. 7 in.	
,, 21	6 ft. 8 in.	
,, 22	6 ft. $8\frac{1}{2}$ in.	
,, 23	6 ft. $8\frac{3}{4}$ in.	
,, 24	Very wet day. In evening, definite slight turn to the south.	
,, 25	6 ft. 10 in., straight.	
,, 27	6 ft. $10\frac{3}{4}$ in., straight.	
,, 28	6 ft. $11\frac{1}{2}$ in., straight.	
,, 30	7 ft. $0\frac{1}{4}$ in., straight.	
,, 31	7 ft. $0\frac{1}{2}$ in., straight.	
June 1	7 ft. 1 in., straight.	
,, 4	7 ft. 2 in., straight.	
,, 5	7 ft. $2\frac{1}{4}$ in., straight.	
,, 11	7 ft. 5 in., straight.	
,, 23	7 ft. 8 in., straight.	

NOTE ON AGAR-AGAR SEAWEED FROM WESTERN AUSTRALIA.

By J. BURTON CLELAND, M.D., Ch.M.

[*Read before the Royal Society of N. S. Wales, June 4, 1913.*]

Dr. J. B. Cleland exhibited an agar-agar seaweed (*Gigastina disticha*, Sonder), kindly forwarded to him from Western Australia by Inspector Abjornsson of the Fisheries Department there. Mr. Abjornsson referred to it as being useful as a demulcent drink. It is apparently closely related to Irish Moss (*Chondrus crispus*). From some of this seaweed nutrient media have been prepared, and solid and sloped tubes of the product were exhibited. The proportions used were those taken for the preparation of ordinary agar-agar media as used in bacteriological laboratories. The tubes showed a remarkably clear product, one almost as transparent as gelatine, and this condition had been obtained without the addition of white of egg for clearing. Apparently a little more of the seaweed is required than of agar-agar, as two tubes inoculated with streptococci and colon bacilli and incubated, had 'slipped' a little and shown an undue amount of water of condensation. Ordinary organisms grew well on the substratum. As a large amount of agar is used in laboratories in Australia and, domestically, it is very useful for making table jellies in warm weather, the occurrence of this plant in Western Australia may be of some economic importance.

NOTES ON EUCALYPTUS, (WITH DESCRIPTIONS OF NEW SPECIES) No. I.

By J. H. MAIDEN.

[*Read before the Royal Society of N. S. Wales, July 2, 1913.*]

An old confusion between *E. tesselaris*, F.v.M., and *E. clavigera*, A. Cunn., with a proposed new variety of the latter.

A. E. TESSELARIS, F.v.M.

This species was described by Mueller, as in the case of so many of his species, from a territory, and not from a specific locality. In *Journ. Linn. Soc.*, iii, 88, he says its habitat is from the south eastern coast of the Gulf of Carpentaria to Moreton Bay, a distance of nearly a thousand miles as the crow flies.

It is a species well defined. It is the so called Moreton Bay Ash, with the lower part of the bark fissured into small, nearly cubical black pieces, like tesseræ.

In B. Fl. iii, 251, Bentham constituted a variety *Dallachiana*, recorded it from Rockhampton, and gave various localities for the normal species. From the localities quoted by him, Careening and Vansittart's Bays, N.W. Coast, *A. Cunningham*, I have seen a specimen, and it is not different from his var. *Dallachiana*. I have not seen Robert Brown's nor Mueller's specimens from the Gulf of Carpentaria. Turning to the "Eucalyptographia," I have seen the specimen from the Finke River, and it is the variety *Dallachiana*.

I have also seen several specimens of var. *Dallachiana* from different localities adjacent to the N.W. Coast (in Western Australian territory) and they are all var. *Dallachiana*.

I have many specimens of *E. tesselaris* (the Carbeen of New South Wales, and the Moreton Bay Ash of Queensland) from northern or rather north western New South Wales to northern Queensland, but I have, so far, not seen an authentic specimen from any other State, and I would suggest that botanists re-examine their material attributed to *E. tesselaris*, as the confusion has caused a good deal of inconvenience as I shall presently show.

B. E. CLAVIGERA, A. Cunn.

This angophoroid species was described from Careening Bay, N. W. Australia, just south of York Sound. The original description says the leaves are petiolate, obtuse and glaucescent.

Bentham (B. Fl. iii, 250) says they are sessile or nearly so, while Mueller ("Eucalyptographia") says much the same, but in greater detail.

As a matter of fact, it is a variable species, and this has given rise to a number of names more or less synonymous, and which I will refer in detail in my "Critical Revision of the genus Eucalyptus."

In its typical form the leaves have a hispid or scabrous surface, but they vary a good deal in length of petiole, width and length of leaf and vestiture.

C. E. CLAVIGERA, A. Cunn., var. DALLACHIANA, var. nov.

The placing of the tree called by Bentham *E. tesselaris*, F.v.M. var. *Dallachiana* under *E. tesselaris* was acquiesced in by Mueller and Bailey, but it has from time to time raised protests. For example,

"The variety *Dallachiana* although described only as such, has certainly all the claims to a separate species, inasmuch as that it totally differs from *E. tesselaris*, at least in bark, leaves and wood. It is the "White Gum" of the settlers, and the "Dangallboora" of the aborigines, and is a middle-sized spreading tree, with a white smooth bark which is entirely deciduous. The adult foliage is

much larger and of a paler hue than that of *E. tesselaris*, and the leaves from adventitious shoots are generally six to thirteen inches long and three to four inches wide. The seedling plants are hispid, with the leaves opposite, broadly ovate and shortly petiolate, but not peltately attached; the seedlings of *E. tesselaris* are also hispid, but the leaves are much smaller and nearly sessile."[1]

In the following passage *E. tesselaris* is the inferior timber, while the durable timber refers to the so-called variety *Dallachiana*.

"Accounts of this timber are conflicting. The Rev. J. E. Tenison-Woods states that about Moreton Bay, Gympie, etc., the wood is not valued for any purpose whatever; about Rockhampton, Mr. O'Shanesy says that the heart-wood is good enough but the sap-wood soon decays; about Townsville and Charters Towers the wood is highly esteemed, and employed for all useful purposes. Mr. Woods says the only way to account for these various statements is by supposing the warmer climate is its proper habitat. This is by no means the only Eucalyptus timber in regard to which statements from different localities are conflicting."[2]

The late Dr. Joseph Bancroft, a keen observer of our flora, wrote as follows, whether in print or in a letter to me, I cannot at this moment say:—

"The wood is heavy and not much used in Brisbane (Moreton Bay Ash, *E. tesselaris*, J.H.M.) for economic purposes, but in the northern part of the colony (the tree under discussion, J.H.M.) it is found valuable, leading to the supposition of the northern tree being of another species. It is very combustible, and dead trees will burn away entirely, root and branch, often without assistance."

The same discordant remarks on the wood are seen in the catalogue of the Queensland Forestry Museum, 1904, under *E. tesselaris*, where we have

---

[1] O'Shanesy, *Contrib. to Fl. Q'land*, p. 40, 1880.

[2] *Proc. Linn. Soc. N.S.W.*, VII, 334, 1883, quoted in my "Useful Native Plants of Australia."

"Not often used in southern Queensland, but extensively for buildings, fences, etc., in the north, where this kind of timber is better, being very tough and durable."

Dr. Joseph's son, Dr. T. L. Bancroft, wrote me as follows in July 1909, from Stannary Hills, North Queensland:

"Bentham's *E. tesselaris* var. *Dallachiana* is not at present in flower; I found it hard to preserve the flowers; they shake to pieces so readily.

"*E. tesselaris* I know well; it occurs here also, but the species under consideration is a totally different species. The leaves are very large and twisted, in the saplings more especially; some few leaves are enormous. The largest trees are about fifty feet high and one foot in diameter. The bark is white or greyish, very like *E. tereticornis*, our Blue Gum. There is no rough bark as in *E. tesselaris*."

The tree is common in northern Qeensland, where it is called "Desert Gum," "Cabbage Gum" or "Pudding wood."

There is no doubt that it is an error to keep it under *E. tesselaris*, but I am not satisfied that it is a distinct species. It is, in my opinion, an extreme form or variety of *E. clavigera*, A. Cunn., with narrow lanceolate leaves. I take Bentham's description of *E. tesselaris* var. *Dallachiana* as typical for my *E. clavigera* var. *Dallachiana*:

"Veins of the leaves more oblique, the intramarginal one not so close to the edge, the cluster of umbels so dense as to be reduced almost to a sessile head." (B. Fl. iii, 251.)

It seems very different at first sight to *E. clavigera*, A. Cunn., of north western Australia, but I have specimens which seem to absolutely connect the two forms. The timber of *E. clavigera* is deep brown and abhorrent to white ants at Darwin; the timber of our "Cabbage Gum" or "Pudding wood" is similarly durable, much more so than that of the Moreton Bay Ash (*E. tesselaris*).

E. leptophleba, F.v.M., _E. drepanophylla_, F.v.M., and _E. siderophloia_, Benth., forma _decorticans_, Bailey.

In the *Queensland Agric. Journ.*, XXVI, 127 (1911) Mr. F. M. Bailey gave the name *E. siderophloia*, Benth., forma *decorticans* to a supposed new Eucalypt from Eidsvold on the Upper Burnett River, Queensland, collected by Dr. T. L. Bancroft.

Ample material of this form and ample material of *E. leptophleba*, F.v.M. have enabled me not only to investigate the Eidsvold tree, but also to throw further light on the imperfectly known *E. drepanophylla*, F.v.M.

This form is known as "Mountain Ironbark," "Naked Top Ironbark," or "Gum Top." It is found in rocky mountainous country on the Upper Burnett, associated with *E. siderophloia*, Benth. To begin with it will be best to formally describe it.

Timber.—Inferior in quality, colour red.

Bark.—On the butt blackish, hard, furrowed, with flattish ridges after the fashion of *E. siderophloia*, but with bare branches as described by Dr. T. L. Bancroft in the following extract from a letter:—

> "A remarkably fine tree, like a large Grey Ironbark, but the branches of the top, up to the size of a man's arm or even thicker, are white in colour; covered with a thin smooth bark; the bark is always peeling off these thin branches, and the ground below is strewn with it after the style of *E. hemiphloia.*"

Juvenile leaves.—Extremely narrow, linear lanceolate, some specimens having an average length of 5 or 6 dm. and a diameter of 8 cm., oil dots abundant, marginal vein distinctly removed from the edge. (These sharply separate this form from any species with which it is likely to be confused. I have no evidence that Mueller ever saw juvenile leaves of this form or of his *E. drepanophylla*, but, if he did, they would afford some explanation of his suggestion that *E. drepanophylla* is a form of *E. crebra*, F.v.M.).

Mature leaves.—Lanceolate, slightly curved, acuminate, equally green on both sides, drying to a pale green, venation (except the midrib) inconspicuous, the lateral veins very fine and somewhat spreading, the marginal vein close to or very near the edge.

Flowers.—Umbels 3 to 6 flowered, usually 3 or 4 together in short axillary or terminal panicles, the peduncles angular. Calyx-tube obconical with one or two angles, tapering into a short pedicel. Operculum blunt pointed, about as long as the calyx-tube. Stamens inflected in the bud, anthers broad, white, opening at the sides, filament at the base, small gland at the top.

Fruit.—Ovoid cylindrical, and 7 mm. in diameter, often with one or two angles, with a darker coloured rim hardly constricted at the orifice, the tips of the valves slightly protruding.

In my *Critical Revision of the Genus Eucalyptus*, Part X, p. 332, I have, following Mueller and Luehmann, combined *E. leptophleba*, F.v.M. and *E. drepanophylla*, Benth. Following are some notes on the bark :—

A. E. LEPTOPHLEBA, F.v.M.

1. Bark dirty grey, rugose, fissured on trunk and persistent on the branches.[1] This is the original description, and appears perfectly clear.

2. "An ironbark," (B.Fl. iii, 221, under *E. drepanophylla*). On what authority it is stated to be an ironbark I know not.

3. Dark persistent rugged bark (*ib.* under *E. leptophleba*). Perhaps this is intended for a free translation of the original description.

4. "Breaking up into numerous small angular pieces in the manner of *E. tesselaris* ("Eucalyptographia" under *E. crebra*, probably following O'Shanesy, as quoted by me in *Critical Revision* X, p. 332, but apparently wrongly, O'Shanesy adopting the name given by Mueller for a tree which, below, I have named *E. Cambageana*).

[1] *Journ. Linn. Soc.*, iii, p. 86, 1859.

5. "A box, hardly to be distinguished from *E. populifolia.*" (Dr. T. L. Bancroft, in a letter to me.)

The tree now described (forma *decorticans*) is very different from *E. leptophleba.* Further material received from Dr. T. L. Bancroft enables me to say that the barks are different; also the juvenile and mature leaves are larger, while the panicles are looser, and the fruit is also larger, as a rule.

E. leptophleba, F.v.M. has *E. Stoneana*, Bailey,[1] as a synonym.

B. E. DREPANOPHYLLA, F.v.M.

1. Bark "Dark grey and ribbed" (B. Fl. iii, 221) original description, quoting Dallachy. This may or may not be a description of an ironbark.

2. "An Ironbark" (B. Fl. iii, 221), quoting Fitzalan, Dallachy, and Bowman.

3. "Perhaps different bark" (to *E. crebra*). ('Eucalyptographia' under *E. crebra.*)

4. "Belongs to the series of ironbark trees, with therefore furrowed and dark coloured bark, ('Eucalyptographia' under *E. hemiphloia*).

There seems no doubt that the true *E. drepanophylla* is an ironbark.

Dr. T. L. Bancroft's Eidsvold specimens and field notes are quite complete, while there is no evidence in the Melbourne Herbarium that Mueller ever saw completely matched specimens of either *E. leptophleba*, F.v.M. or *E. drepanophylla*, F.v.M.[2]

That is why he threw doubt upon his own two species on several occasions, and systematists will always be liable to

[1] *Queensland Agric. Journ.*, XIII, p. 259, 1909.

[2] I suggest that Bentham (B. Fl. iii, 221) on Mueller's behalf, compiled the description from specimens from different localities.

make mistakes when they have to deal with incomplete material, and, through attempting to match material from different sources are led to make inferences. Even with complete material from a specific locality, the question of variation must also be borne in mind.

I also received complete material and field notes of *E. leptophleba* from Dr. T. L. Bancroft from Stannary Hills, North Queensland, and I am now led to submit the following propositions:—

1. *E. leptophleba* F.v.M. and *E. drepanophylla*, F.v.M. are distinct species, the former being a Box and the latter an Ironbark.

2. The following specimens are correctly referable to *E. drepanophylla*, F.v.M.

(*a*) Port Denison ; also Burdekin Expedition, *Fitzalan* (evidently the type).

(*b*) Cleveland Bay (*S. Johnson*). Both specimens in bud and flower only.

(*c*) Ravenswood, Burdekin River (*Johnson*). In fruit only, labelled both *drepanophylla* and *crebra* by Mueller.

3. *E. siderophloia*, Benth. forma *decorticans* Bailey is referable to *E. drepanophylla*, F.v.M.

E. siderophloia, Benth. and its relation to *E. paniculata*, Sm. in Queensland.

The form (*decorticans*) above referred to, cannot belong to *E. siderophloia* because of the bark and timber, while the juvenile leaves are wholly dissimilar, to mention no other difference. Investigation of the relations of *E. drepanophylla*, F.v.M. with *E. siderophloia*, Benth., has caused me to submit the following brief notes in regard to the latter species and *E. paniculata*, Sm. in Queensland.

A. In Part X, p. 325 of my *Critical Revision*, I have stated that, in my opinion, *E. siderophloia*, Benth. is always rostrate-budded, and that the attempted establishment of a rostrate variety is founded on misapprehension. So far I have seen no evidence that this view is an erroneous one.

B. There is a good deal of a Grey Ironbark in Queensland which has a conical operculum and a paler timber than the rostrate-budded Eucalypt above referred to, which has always a deep red timber.

Bailey deals with these two ironbarks in his *Queensland Flora* in the following manner :—

C. *E. siderophloia*, Benth. var. *rostrata*. "*Large leaved* Iron Bark." Wood *red*, (the italics are mine). About Taylor's Range near Brisbane, (p. 621).

I look upon this as *E. siderophloia*, normal form.

D. *E. siderophloia*, Benth. "Black Ironbark." Common in the southern portions of the Colony. Wood of a *grey* colour (the italics are mine) (p. 621).

I submit that this tree is *E. paniculata*, Sm.

E. Then under *E. paniculata*, Sm., he says "In southern inland localities," (p. 616). This seems to me correct as far as it goes.

F. Incidentally I may say that *E. paniculata*, Sm., is referred to as Red Ironbark by Mueller in "Eucalyptographia" by a mistake on the alleged authority of the late Rev. Dr. Woolls who, in his own copy of that work (in my possession) cancelled the word "red" and inserted "white." The student of New South Wales Eucalypts knows that to the vast majority of people *E. paniculata* goes under the name of White or Grey Ironbark, while some people, noting its pink or pale red colour (sometimes deeper in tint, but never as deep a red as *E. siderophloia*), use the name Red Ironbark, but, compared with a true Red Ironbark the term is very misleading.

My suites of specimens of the Grey Ironbark of Queensland are neither as numerous nor as complete as I would like, and in some of them the anthers vary somewhat from those of the anthers of the typical form of *E. paniculata*, Sm., as found at Port Jackson, but the present state of our knowledge causes me to submit that the Grey Ironbark of Queensland is not specifically different from the Grey Ironbark of New South Wales, and that it is usually *E. paniculata*, Sm. At the same time, the term "grey" is sometimes given with reference to the prevailing colour of the bark, and it is more or less appropriate when applied to other species also.

I desire to remark that the "egg-in-eggcup" character of the operculum sometimes occurs in *E. paniculata* as well as in *E. siderophloia*.

* * * * * *

The following are suggested as new species :—

1. E. HYBRIDA, n. sp.

Type from Concord, Sydney, N.S.W. (Rev. Dr. Woolls, 1890 ; R. H. Cambage, 10th February 1901).

Arbor erecta, altitudine circiter 50 pedes. Cortex cinerea, lævis, corrugata. Lignum pallidum, durum. Folia matura lanceolata vel late lanceolata, pallida virentia, tenuiora, circiter 8 – 12 cm. longa, vena peripherica margini approximata, venis lateralibus patentibus. Flores in breve panicula corymbosa, quaque plerumque 3 – 6 flora. Calycis tubus conoideus. Operculum acuminatum, calcis tubo æquilongum. Fructus cylindrico-conoidei, circiter 6 mm, lati, in orificium leniter contracti, margine tenui. Valvarum apices plusve minusve depressi, orificium rare tangentes.

Mr. Henry Deane[1] and I drew attention to a Eucalypt which we had received from Mr. R. H. Cambage, and which

---

[1] *Proc. Linn. Soc. N.S.W.* XXVI, p. 340, (1901).

we thought presented an instance of hybridism. Later on[1] I stated that I had no doubt as to its hybrid nature. I have had the tree under observation ever since, and am of opinion that it is a form sufficiently distinct to receive a name, and suggest the above, which is appropriate, since the evidence is remarkably conclusive that *E. paniculata*, Sm. and *E. hemiphloia*, F.v.M. are its parents.

It was originally found in Bray's Paddock, Concord, near Sydney, where I knew of six trees until recently, but building operations may soon exterminate these particular specimens.

Dr. J. B. Cleland has drawn my attention to a tree on Milson Island, Hawkesbury River, (a short distance west of the Railway Bridge) which appears to be identical with that from Concord. *E. paniculata*, Sm. is common on the Island, but there is no *E. hemiphloia*; this suggests that the hybrid originated elsewhere than on Milson Island.

E. hybrida may be described as follows :—

An erect tree of about 50 feet high, the tips of the branches smooth, the butt with a sub-fibrous (peppermint-like) or flaky-fibrous and more or less flat-corrugated bark, greyish or blackish externally, hence some trees have been described as "Black Box."

Timber pale-coloured, hard, interlocked, and probably valuable.

Juvenile foliage not seen in the strictly opposite state, but as seen, not different from the mature foliage except in width.

Mature foliage. Lanceolate or broadly lanceolate, slightly falcate, acuminate, commonly 8 to 12 cm. long. Dull green, the same colour on both sides, rather thin and tough, lateral veins spreading, fine, the intramarginal vein not far removed from the edge of the leaf, oil dots not numerous.

Flowers. Peduncles of moderate length, angular, usually in a short corymbose panicle, each with about 3 to 6 or sometimes more

---

[1] *Op. cit.*, xxx, p. 498, (1905).

flowers. Calyx-tube conoid, 5 cm. diameter, often angular, tapering into a short pedicel. Operculum pointed and as long as the calyx-tube. Stamens inflected in the bud, anthers small, yellow, opening in small slits near the top, filament at base, and small gland at back, indubitably showing intermediate characters between the anthers of *E. paniculata* and *E. hemiphloia.*

Fruit. When immature cylindrical, with a rim round the orifice; when ripe cylindrical to almost conoid, about 6 mm. in diameter, hardly constricted at the orifice, rim thin, tips of valves more or less sunk and rarely flush with the orifice.

The *Affinities* of this species are almost intermediate between *E. paniculata*, Sm., the Grey Ironbark, and *E. hemiphloia*, F.v.M., the Grey Box.

This is the first species of this genus which has been named with especial reference to its hybrid character. I have a large number of instances of apparently indubitable hybrids, but in most cases a pictorial illustration is necessary to make the hybridism clear, and therefore I propose to describe them in my "Critical Revision" of the genus.

2. E. Bakeri, n. sp.

Local Name "Mallee Box."

Type from Ticketty Well, Wallangra, N.S.W. (E. H. F. Swain, July 1911). Collected also by Mr. J. L. Boorman, December 1912.

Frutex altus similis Mallee, vel arbor parva 30 – 50′ alta. Trunci cortex dura et squamosa. Ramuli læves. Lignum durum, grave, rubrum. Folia juvena obscuro-virentia, concoloria, linearo-lanceolata, vix acuminata, 9 cm. longa, 1 cm. lata, oleosa, indistincte venosa, penniveniis, vena peripherica a margine remota. Umbellæ plerumque axillares, multifloræ, sæpe 10 – 13 floræ. Operculum elongatum calycis tubo multo longiore, cujus diameter leniter latior est. Fructus diametro circiter 5 mm., truncato-spheroidei. Valvarum apices subulati, 2 mm. exserti.

A large shrub or small pendulous Willow-like tree attaining a height of 30 - 50 feet, forming a single stem, or stooling from the ground.

Bark dark box-like, or hard and scaly up to its branches, falling away in long flakes, rough at the butt, branches clean, bluish-green or pale-yellow to white right up to the tips.

Wood hard and heavy, of a deep red when freshly cut, becoming browner with age, the grain of the timber fibrous, very tough, reputed to be an excellent timber for wheel-wrights' work.

Juvenile leaves dull green on both sides, linear-lanceolate, hardly acuminate, about 6 or 7 cm. long, the venation not distinct, the intramarginal vein close to the edge, the lateral veins penniveined, plentifully besprinkled with oil-dots and the branchlets angular and glandular.

Mature leaves linear-lanceolate, petiolate, acuminate or with a hooked tip, bright green, dull-shiny, richly covered with oil-dots, venation indistinct, the intramarginal vein distinct from the edge, the lateral veins penniveined. Average dimensions 9 × 1 cm.

(If this species were gregarious, it would probably be found to be a valuable oil-yielding species).

Flowers. Umbels mostly axillary and flowers numerous, often 10 - 13 in an umbel, which sometimes takes on a stellulate appearance. Operculum elongated, very much longer than the calyx-tube, which is of slightly increased diameter, and which tapers, somewhat abruptly, into the short pedicel. The common peduncle about 1 cm.

Anthers small, renantheroid, but the two cells more united than in the Renantheræ; spherical gland at top and back.

Fruits. Small, about 5 mm. in diameter, truncate-spheroid, the tips of the valves awl-shaped and protruding 2 mm. from the orifice.

Enclosing the valves and torn by the tips of them as the fruit ripens is a thin white membrane, which gives the rim

and orifice a whitish appearance, and which, if present in all, is only obvious in a few species of this genus.

Affinities. It is a remarkable narrow-leaved species, with narrow juvenile foliage, buds with long opercula of less diameter than the calyx-tube, and small fruits with well exserted awl-like tips.

It is not easy to indicate its closest affinity.

It would appear to have affinity to *E. uncinata*, Turcz., but Mr. Boorman, an experienced collector, is emphatic that the two species are very different in habit. *E. Bakeri* is a tree of 50 feet and even more, reminding one of a Willow; indeed it was first sent in as "Willowy Eucalypt" The foliage is narrow and somewhat dull in appearance; the anthers are very similar, but not identical, while there is no kink in the filament in the stamens of *E. Bakeri.*

It approaches *E. odorata* in its mode of growth; it seems closest to the var. *Woollsiana* of that species, but its buds and fruits are quite different. The same observations may be made in regard to *E. acacioides*, A. Cunn., (*E. viridis*, R. T. Baker).

Its fruits remind one of those of the Western Australian *E. salmonophloia*, F.v.M., but those of the latter species are smaller, more shiny, have thinner and more marked pedicels.

E. Seeana, Maiden, is another species with small fruits (which are, however, domed), and a long operculum (more tapering into the calyx-tube in *E. Seeana*), leaves different and the bark of *E. Seeana* is smooth.

E. redunca, Schauer var. *angustifolia*, Benth. is another narrow-leaved, long operculumed form. It is from South-western Australia and has no close affinity to the present species.

Other narrow-leaved species are *E. angustissima*, F.v.M. and *E. apiculata*, Baker and Smith, but they have no special affinity to this species.

E. oleosa, F.v.M. bears an obvious resemblance as far as the fruits are concerned, but those of the new species are smaller, and in leaves, and in most other respects the affinities are not obvious.

This is a specially interesting species, rich in oil, which I name in honour of Mr. Richard Thomas Baker, who has done valuable work in connection with this genus.

E. SIMILIS, nov. sp.

Type from "Desert Country west of Emerald, Queensland (G. H. Carr, March 1908).

Arbor mediocris. Folia juvena tenua, glabra, pedunculata, ovato-acuminata. Folia matura angusto-lanceolata, flavo-virentia, concoloria, circiter 12 cm. longa, 2 cm. lata. Venæ laterales pinnatæ, distinctæ, vena peripherica distincta et a margine remota. Umbellæ confertæ, multifloræ plerumque in panicula terminale corymbosaque. Calycis tubus irregulariter costatus. Operculum hemisphæricum vel umbonatum. Fructus vix 1 cm. longi, truncato-ovoidei, in orificium sensim contracti.

A tree of medium size; notes on bark and timber uncertain.

Juvenile foliage. Thin, parchment-like, perfectly glabrous, not seen strictly opposite, pedunculate, ovate-acuminate. Size of a specimen 6 × 3 cm.

Mature foliage. Narrow lanceolate or slightly falcate, petiolate, the petioles flattened and twisted, length of blade up to 12 cm. and more with a greatest width of about 2 cm. Equally yellowish-green on both sides, rather shiny, venation distinct, and nearly as prominent on the upper as on the lower side. Midrib very prominent, lateral veins pinnate and very distinct, the intra-marginal vein distinct and removed from the edge.

Buds and flowers. Inflorescence profuse, in a loose umbel, several flowered, mostly in a terminal corymbose panicle, the peduncles slightly compressed or angular, calyx-tube irregularly ribbed, shiny; opercula hemispherical or umbonate, shiny. Filaments yellow, anthers with long narrow adnate cells with a moderately large gland at the back, and the filament attached half way up.

Fruits. Sharply separated from the short pedicel, on a slightly flattened common peduncle of about 1·5 cm. Truncate-ovoid, gradually constricted towards the orifice, barely 1 cm. long and about 6 mm. at the orifice. Three-valved, the valves blunt and these capsule teeth not adherent to the calyx-tube.

Habitat. Desert country west of Emerald, Queensland.

Affinity. Its closest affinity, so far as is known, is *E. Baileyana*, F.v.M. (see description amended by me in *Forest Flora N.S.W.*, iv, 71). Like that species it is a member of the section Eudesmieæ, and appears to differ from *E. Baileyana* in the following characters :—

1. *E. similis* is said to be a "Yellow Gum," or "Yellow Jacket," while *E. Baileyana* is a "Black Stringybark."

2. The mature leaves of *E. similis* have the same colour on both sides, and have shorter peduncles, while the juvenile leaves are glabrous, those of *E. Baileyana* being covered with stellate hairs.

3. The fruits of *E. similis* are, in comparison with those of *E. Baileyana*, cylindroid, those of *E. Baileyana* being almost spherical, darker and much larger.

The specific name is given in view of the affinity of this species to *E. Baileyana*, F.v.M.

4. E. Cambageana, n. sp.

Local Name "Blackbutt."

Type from Mirtna Station, Charters Towers, Queensland (Miss Zara Clark, January and December 1912.)

Arbor alta Blackbutt vocata, ramis longis pendulisque. Trunci, cortice cinerea et squamosa altitudini 3 – 4 pedes, a caule laeve et albo ramisque distincte disjuncta. Lignum rubrum. Folia juvena 15 cm. longa, 2·5 cm. lata, pallido-virentia utrinque, concoloria, ovata vel pyriforma, vena peripherica patente et a margine distincte remota. Umbellæ 3 – 8 in capite, paniculas plerumque terminales formantes. Alabastri clavati. Operculum ovoideum et calycis tubo circiter dimidio superante. Fructus parvi, conoidei, diametro circiter 7 mm. orificio.

"The young trees grow tall and fairly straight, but with age they become pipy and eventually simply a shell. Very liable to be attacked by white ants." (Miss Zara Clark).

"The trees range from 50 – 80 feet high, having long pendulous branches.

"They have scaly bark permanent up to 3 – 4 feet from the ground; this is hard and of an ironbark nature, jet black in colour, the remainder of the stem being milky-white, approaching bluish-white (glaucous); it is clear of any sign of ribbony bark beyond the butt. There is a distinct line of demarcation between the rough black and the white clean stem.

"The sapwood is exceptionally thin, the heart wood deep red or chocolate in colour, hard, heavy, long and tough in the grain, much resembling that of the Red Box (*polyanthemos*) of New South Wales.

"It is the most important timber in the Emerald district for all purposes, being sound, and yielding long, clean stems of many feet in length, hence exceptionally suitable for milling purposes." (J. L. Boorman.)

Juvenile leaves. Pale-coloured, equally green on both sides, rhomboid-ovate to pyriform and broadly lanceolate, petiolate, apex blunt, venation prominent, marginal vein at a considerable distance from the edge, the lateral veins spreading. Oil dots not obvious. Average size say 9 to 12 cm. × 5 or 6 broad.

Mature leaves. Lanceolate, slightly curved, petiolate, thickish, shiny, pale-coloured, equally green on both sides, venation prominent, the intramarginal vein distinctly removed from the edge, the lateral veins spreading. Average length of mature leaves 15 × 2·5 cm.

Flowers. Umbels three to eight in the head, forming usually terminal panicles, buds clavate, the calyx-tube forming a defined raised border at its junction with the operculum, the calyx-tube tapering gradually into the pedicel, the operculum ovoid and about half the length of the calyx-tube.

Anthers belonging to the Porantheræ, pores small, opening at the side, the filament always at the base, and the small gland always at the top.

Fruits. Small, conoid, the calyx-tube tapering with but slight abruptness into the pedicel; when young, with a well defined grooved rim, which almost disappears on ripening, leaving a dark brown rim, tips of the valves sunk or rarely flush with the orifice. Size about 7 mm. diameter at the orifice and length the same.

Habitat. "Grows on hard clay soil, often stony, and always some distance from water. Generally in clumps and often in company of Gidgee and Brigalow in the Charters Towers district." (Miss Zara Clark).

Reid River, a few miles south of Townsville (N. Daley).

"The principal timber of the Emerald district, noted for its hardness and size and for the good quality of its timber. Apparently local from Gin Gin to within 10 – 12 miles east of Alpha." (J. L. Boorman).

Some poor fruits collected by O'Shanesy from the Dawson and Mackenzie Rivers, labelled *E. leptophleba* by Mueller, are the present species. These were referred to by me in *Crit. Rev. Gen. Eucalyptus*, x, 333, where I doubted the naming of the specimen. It might be neglected altogether but for the reason that (*op. cit.*, p. 333), it evidently formed

the basis of the name *E. leptophleba* attached by O'Shanesy to a Blackbutt whose timber and bark he describes. He says, "dispersed through the scrubby country westward from Goganjo."

It is therefore widely diffused in the warmer parts of Queensland, but we do not know its precise range yet.

Affinity. It would appear to take the place, in Queensland, of the more southern *E. polyanthemos*, Schauer, or rather of its narrow-leaved forms. The anthers, however, sharply separate them.

The leaves also are different both in shape and venation. The rough bark is more scaly than that of *E. polyanthemos*, and the line of demarcation more clearly defined.

It is named in honor of Mr. Richard Hind Cambage, who has done valuable work in connection with this genus. *E. Cambagei*, Deane and Maiden, is conspecific with *E. elæophora*, F.v.M.

E. PILULARIS, Sm. var PYRIFORMIS, nov. var.

Bucca Creek, near Coff's Harbour, N. S. Wales. (A. H. Lawrence, J. L. Boorman).

Type, J. L. Boorman, June, 1911.

A tall, sound "Blackbutt" 4 to 7 feet in diameter, bark ribbony up to or beyond the third or fourth branches. Bark on the butt similar to that of the normal species. Branchlets often glaucous and double opercula common.

Fruit large, often pyriform, commonly 1·5 cm. long × 1 cm. broad in the dried state.

NOTE ON THE PARAFFINS OF EUCALYPTUS OILS.

By HENRY G. SMITH, F.C.S.

[*Read before the Royal Society of N. S. Wales, July 2, 1913.*]

The first member of the paraffins, belonging to the aliphatic series, found in Eucalyptus oils, was isolated last year from the product of *Eucalyptus acervula*, Hook. f., the 'Red Gum' of Tasmania. The characteristic features of this substance were fully described in a paper "Research on the Eucalypts of Tasmania," by Mr. R. T. Baker and myself.[1] This paraffin stearoptene is a saturated hydrocarbon, and thus, most probable, belongs to the $C_n H_{2n} + 2$ group; it resembles in appearance, odour on ignition, and behaviour, the solid paraffins derived from mineral oils, and known generally as "paraffin wax."

The melting point, taken by the capillary tube method, of the paraffin from this species of Eucalyptus was 55 – 56° C. Although the substance was isolated and purified from the oil of *E. acervula* from material collected from two different districts in the island, yet, the melting point did not vary. It is not thought, however, that it is a simple hydrocarbon, but probably consists of two or more homologues. The reasons for this are that the melting point does not agree with any known member of the series, that the paraffin from the oil of *E. Smithii* melts at a higher temperature, also that a similar substance from rose oil, which melts at 35° C. has been separated by distillation into two bodies, one melting at 22° and the other at 40° C. *E. acervula* is not the only species of Eucalyptus in which the paraffins occur, and already these bodies have been isolated from the oil of

[1] Proc. Roy. Soc. Tasmania, October, 1912.

E. paludosa, and more recently from the oil of *E. Smithii.* They probably occur in the oils from numerous species, but are present in very small quantities, which probably accounts for the fact that up to very recently these substances have escaped observation. The object of the present note is to record the presence and properties of the paraffin from the oil of the last species.

The crude oil of *E. Smithii*, R.T.B., from which the paraffin was isolated, was distilled by Mr. D. E. Chalker, from material grown naturally at Hill Top, in this State, and was rectified at the Technological Museum. The method whereby the paraffin was separated and purified was to steam distil the crude product until no more oil came over, then to separate the residue and treat it with cold alcohol; this precipitated the paraffin, the oil and impurities remaining largely in solution. The precipitate was filtered off, dried, dissolved in hot ethyl acetate, from which it separated out again on cooling, thus further removing impurities. The paraffin was somewhat dark coloured at this stage; it was then boiled in alcohol with animal charcoal, filtered boiling hot, repeating the process until all had been dissolved. As the alcohol cooled the paraffin separated, and it appears to be almost insoluble in cold alcohol. The precipitate was then dried on porous plate, finally dissolved in chloroform and again precipitated by alcohol. As thus prepared it was quite white and odourless, and melted at 64° C. by the capillary tube method. It differed in no other respect than the melting point from the similar substance extracted from the oil of *E. acervula.* It was a saturated paraffin and was remarkably stable towards concentrated acids and oxidising substances in the cold. The higher melting point of the paraffin from the oil of *E. Smithii* over that from *E. acervula* is perhaps one distinguishing feature between the oils of the members of the different groups; and it may

be that eventually a paraffin with even a higher melting point will be isolated from the oils of other Eucalyptus species.

The aliphatic paraffins cannot be considered as very uncommon constituents in essential oils, and their presence has been shown in the oils of more than a dozen different plants. Those containing paraffin in greatest amount are rose oil and chamomile oil; and in these the stearoptene is often so abundant that the oil congeals on cooling. The paraffin recorded from neroli oil melts at exactly the same temperature as that from the oil of *Eucalyptus acervula*, while that in chamomile oil only differs by one degree. No less than eight paraffins have been recorded from other essential oils the melting points of which are within one degree of that isolated from the oil of *E. Smithii*. If the paraffin from this species is considered as a homogeneous substance, then its formula would probably be $C_{29}H_{60}$; at any rate, the number of carbon atoms in the molecule must be very high.

What part these paraffins play, if any, in the formation of other aliphatic constituents of Eucalyptus oils is at present quite unknown.

THE SEEDLINGS OF THE ANGOPHORAS WITH DESCRIPTION OF A NEW SPECIES.

By CUTHBERT HALL, M.D., Ch.M.

(Communicated by R. T. BAKER, F.L.S.)

With Plates II - IV.

[*Read before the Royal Society of N. S. Wales, August 6, 1913*]

LUBBOCK in his work "On Seedlings" has described the seedlings of ten of the Eucalypts, and one Tristania, viz.:—*T. conferta*, but makes no mention of the Angophora seedlings, and it is to remedy this omission that this study was begun. An investigation of the seedlings, not merely increases our knowledge of plants, but it puts in our hands frequently a means of differentiating species and varieties that is likely to be of very great value. This is afforded both by the information gained from the form of the cotyledon leaves, and also that of the primary or juvenile leaves, which so frequently differ from those of the mature plant.

The seedlings of the Angophoras bear a striking resemblance to those of the lower species of the Eucalypts, viz., the "Bloodwoods," such as *E. calophylla*, *eximia*, *corymbosa*, etc., a fact which bears out the resemblance in respect of the venation of the leaves and chemical constitution of the trees generally, noted by Messrs. Baker and Smith.

Cotyledons.—These are all of large dimensions and foliaceous, *A. cordifolia* and *A. lanceolata* being much larger than those of the other species. The cotyledons of *A. cordifolia* are orbicular while those of the others are more or less reniform. They are all cordate at base, glabrous and petiolate. The convex margin is always

entire as in the "Bloodwoods," and shows none of the emargination seen in the higher Eucalypts, as *E. globulus.* The venation is well marked, three to five veins breaking up into finer ones, which unite in a looping arrangement.

Leaves.—In all species these are opposite, and this character is maintained in the adult, there being practically no passing into the alternate arrangement usual in the Eucalypts. The primary or juvenile leaves are entire, sessile, cordate at base, decussate, exstipulate, covered with glandular hairs.

Stem is erect, terete, bristly, herbaceous, ultimately woody.

A. CORDIFOLIA, Cav.

Hypocotyl short, 3 mm.

Cotyledons large, foliaceous, with long petioles (apparently to compensate for the shortness of hypocotyl), entire, glabrous, orbicular, veins prominent, laminæ 1·5 cm. in diameter, petioles 1 cm., flattened and grooved on upper side at the junction with laminæ.

Leaves—First pair alternate and rudimentary, the first barely perceptible, the second a short spur 2 mm. long. Following leaves entire, opposite, decussate, ovate or orbicular, sessile, cordate at base with rounded auricles, thickly covered with glandular hairs; venation open, parallel, intramarginal vein close to edge. Second pair of leaves 0·5 cm. × 0·3 cm., third 1·1 cm. × 0·8 cm., fourth 1·3 cm. × 1 cm. Stem bristly, first and second internodes 1·2 cm., third 1·3 cm.

A. SUBVELUTINA, F.v.M.

Hypocotyl glabrous, terete, 1 cm.

Cotyledons large, foliaceous, reniform, smaller than those of *A. lanceolata,* laminæ 1·2 × 1 cm., petiole 0·5 cm.

Leaves entire, opposite, decussate, obtuse, ovate, sessile, cordate at base with rounded auricles, paler on under surface when dry, covered with fine glandular hairs, venation open, parallel, intramarginal vein ill-defined. First pair of leaves 1·5 cm. × 0·9 cm., second pair 0·7 cm. × 1·2 cm., third 3·6 cm. × 1·5 cm., fourth 5 cm. × 2 cm. Stem erect, greenish, terete, bristly, first internode 1·5 cm., second 1 cm., third 1·3 cm.

A. INTERMEDIA, DC.

The seedlings of this are almost identical with those of *A. subvelutina*. When grown under similar conditions they are usually quite indistinguishable, and it is only when *A. intermedia* is a foot or two high, and nine or twelve months old, that the leaves begin to be petiolate.

A. LANCEOLATA, Cav.

Hypocotyl erect, terete, glabrous, reddish, 1·5 cm. long.

Cotyledons large, foliaceous, glabrous, petiolate, reniform entire, except at base which is cordate, veins prominent, purplish red on under surface, laminæ 15 × 13 mm., petioles 6 mm.

Leaves entire, opposite, decussate, lanceolate, obtuse, sessile, cordate at base with rounded auricles, paler on under surface when dry, purplish-red in early stage, covered with fine glandular hairs, lateral veins open and parallel, intramarginal vein not well defined, but in older leaves close to edge. First pair of leaves 2·8 cm. × 0·6 cm., second pair 8 cm. × 0·8 cm., third 3·5 cm. × 1 cm. Stem terete, reddish, bristly. First internode 2 cm., second 2 cm., third 1·8 cm.

A. MELANOXYLON, R. T. B.

Hypocotyl 1·3 cm., reddish, glabrous.

Cotyledons reniform, entire, except at cordate base, glabrous, petiolate, reddish-purple on inferior surface, laminæ 1 cm. × 0·8 cm., petioles 0·3 cm.

Leaves entire, opposite, decussate, lanceolate, obtuse, subsessile, rounded at base or with rounded auricles, glabrous or with few glandular hairs, paler on inferior surface when dry. First pair 1·8 × 0·6 cm., second 2 × 0·7 cm., third 2·5 × 1 cm. Stem green, terete, finely pubescent or with a few bristles. First internode 1·5 cm., second, third and fourth 1 cm.

A. Bakeri, sp. nov.

Cotyledons similar to those of *A. subvelutina*, *intermedia*, and *melanoxylon*.

Leaves entire, opposite, decussate, narrow-lanceolate, subacute then acute, cordate at base with rounded auricles, glabrous or few bristles on under side of midrib, venation inconspicuous, lateral veins closely set and parallel, intramarginal vein ill-defined and close to edge. First pair of leaves 6 × 2 mm., second 8 × 3 mm., third 10 × 3 mm. Stem terete, greenish, pubescent or few bristles. First internode 9 mm., second 6 mm., third 6 mm.

Remarks.—In the ascending scale judged by the seedlings, I would place the Angophoras as follows:—

A. cordifolia.
|
A. subvelutina.
|
A. intermedia.
|

A. lanceolata.	*A. melanoxylon.*	*A. Bakeri.*

This agrees with the classification arrived at by Messrs. Baker and Smith on botanical and chemical grounds, from examination of the mature trees. The seedling of *A. cordifolia* is most distinct from all the others, the cotyledons being larger and orbicular, the first pair of leaves are alternate and rudimentary, while the following leaves are ovate and more hirsute than those of the other Angophoras. The

seedling is also slender and grows slowly. From close and extensive field knowledge in the County of Cumberland, extending over many years, I have found all degrees of gradation between *A. subvelutina* and *intermedia.* In its most typical form the former is to be found growing by creeks and rivers and on deep alluvial flats. When seen on the hillsides, one frequently finds a divergence from type, the leaves are narrower and longer, and tend to lose the juvenile sessile form, and to become petiolated. This is especially so in the terminal branches of old trees, but even on the banks of the Parramatta River, one can find trees less subvelutina-like than others.

A. intermedia grows most characteristically on the Wianamatta Clay where it is shallow, and the roots can penetrate readily through to the Hawkesbury Sandstone as found to the north of Parramatta, occurring in association with *Eucalyptus saligna*, *acmenoides*, *punctata* and *pilularis.* It is not till the seedlings are twelve months old that they can be distinguished from those of *A. subvelutina*, and sometimes even not till long after that. As in the adult stage, these two species are found to be almost identical in buds, fruit, flowers, timber, bark and chemical constitution, it will be seen that the only salient difference is in the adult leaves.

In the Angophoras an interesting gradation is to be found in the juvenile leaves, those of *A. cordifolia* being small, ovate, or even orbicular, then in *A. subvelutina* and *intermedia*, they are longer but still ovate, in *A. lanceolata* they are lanceolate, in *A. melanoxylon* they are narrower, and in *A. Bakeri* narrowest of all.

While all the juvenile foliage is sessile and cordate, and in *A. cordifolia*, *subvelutina* and *melanoxylon* this character is retained through life, in *A. intermedia*, *lanceolata* and

Bakeri the mature leaves are petiolate. This heterophylly corresponds to what is so usual in the Eucalypts.

The evidence of the seedlings strongly supports Mr. Baker's view that *A. melanoxylon* is deserving of specific rank. Not only this but it also conclusively proves, along with the results of the oil distillation, that the narrow-leaved form that was figured first in the "Sydney Mail," February 1st, 1890, by Mr. J. H. Maiden, and is referred to by Mr. R. H. Cambage as *A. intermedia* var. *angustifolia*[1] is really far more distinct and more deserving of specific rank than *A. intermedia* as compared with *A. subvelutina*. I will therefore describe it, and have the great pleasure of naming it *Angophora Bakeri*, after Mr. R. T. Baker, who preeminently deserves to be associated with such an important Natural Order as the Myrtaceæ.

A. BAKERI, sp. nov.

(Arbor, 20 – 30 ped. alta, "Narrow-leaved Apple" nota, cortice rimosa, ramulis glabris vel setosis; foliis juvene augustis sessilibus basi cordatis, foliis mature augustis $1\frac{1}{2}''$ – $3''$ longis $\frac{1}{3}''$ latis, lanceolatis falcatis acuminatis petiolatis oppositis, veins lateralibus parallelis, vena peripherica prope margini posita; terminalibus corymbis vel brevibus paniculis; calycis tuba $2'''$ – $3'''$ lata, turbinata glabra dentibus acutis; fructus $4'''$ – $5'''$ longus, costis longitudinalibus haud prominentibus, margine tenue contracto incurvato, dentibus brevissimis acuminatis.)

A medium sized tree, 20 – 30 feet high, with a diameter seldom exceeding 2 feet; bark fibrous, resembling that of *A. subvelutina*, F.v.M. and *A. intermedia*, DC. Branchlets glabrous or with bristles. Leaves numerous $1\frac{1}{2}$ – 3 inches long, rarely more than $\frac{1}{3}$ inch broad, narrow-lanceolate, petiolate, acuminate, falcate, opposite, when dry paler on

[1] Notes on Native Flora, Proc. Linn. Soc. N.S.W., Vol. xxxvi, Part 3.

the underside, glabrous, lateral veins numerous fine parallel, indistinct on upper surface, intramarginal vein very close to edge, oil dots visible. Flowers in dense terminal corymbs, or short panicles; calyx 2 – 3 lines in diameter, turbinate, glabrous, teeth acute; petals white, imbricate, abruptly acuminate, separately deciduous or occasionally coming away together in a sort of operculum. Fruit slightly larger than that of *A. subvelutina*, 4 – 5 lines long, 3 – 4 lines broad, longitudinal ribs not prominent, rim thin, contracted, incurved, teeth very short acuminate.

Habitat.—Coastal district of New South Wales on Hawkesbury Sandstone around Sydney and usually associated with *Eucalyptus haemastoma* and *corymbosa.*

Timber.—A pale coloured timber, of medium weight, with a pinkish duramen and pronounced alburnum readily attacked by borers. Gum veins fairly prevalent. It dresses well, is open in the grain and fissile, and specimens free of gum veins and sapwood could be turned to economic use, such as some forms of cabinet timber, and general carpentry work.

Remarks.—Bentham (Flora Aust.) does not mention this form at all. It has usually been confused with *A. intermedia.* Anyone seeing these two trees in the field could never confuse them, as *A. Bakeri* can be distinguished by its numerous narrow leaves, which droop in characteristic fashion owing to the long petioles, and it forms a shorter, broader tree than *A. intermedia.* The fruit of the former is also slightly larger and asymmetrical on its pedicel, the rim contracted and teeth very short and acuminate. Moreover it yields an oil and oil dots may be seen in the green leaves, whereas *A. intermedia*, like *A. subvelutina*, yields no oil or only traces. Taking all things into consideration therefore, I consider this a far stronger species than *A. intermedia.* As pointed out before, the seedlings of *A.*

Bakeri are quite distinct, and I have found the seedlings of the two species growing together in the same soil and yet absolutely retaining their characteristics.

EXPLANATION OF PLATES.

PLATE II.—1. *Angophora intermedia* (naturally grown).
2. *Angophora subvelutina* (grown in box).
3. *Angophora cordifolia* (grown in box).

PLATE III.—1. *Angophora melanoxylon* (grown in box).
2. *Angophora Bakeri*, sp. nov. (naturally grown).
3. *Angophora lanceolata* (grown in box).

PLATE IV.—*Angophora Bakeri*, sp. nov. 1. Flowering twig. 2. Bud (enlarged). 3. Anther (enlarged) 4. Fruits.

ON THE ESSENTIAL OILS OF THE ANGOPHORAS.

By HENRY G. SMITH, F.C.S.

[*Read before the Royal Society of N. S. Wales, August 6, 1913.*]

Introduction.

THIS genus, Angophora, was established by Cavanilles in 1797, the name being given by him to two species common in the neighbourhood of Sydney, viz.:—*Angophora cordifolia* and *lanceolata.* Although very closely allied to that widely distributed Australian genus—Eucalyptus, and in all probability its prototype, yet the number of species in the genus is very limited, only six being so far described, as against about two hundred in the former. With the exception of *A. cordifolia,* they are all fine forest trees, and so much resemble those of the cognate genus *(supra)* that they are commonly regarded as the same "family," and this is very excusable to the unscientific mind, for the barks are almost identical and could easily be classed as "Stringy-bark," or "Gum"—smooth bark. The timbers also very closely resemble those of the pale coloured woods of the Eucalypts. Botanically, they are only to be differentiated from the Eucalypts by their distinct calyx teeth and free petals.

In geographical distribution they are restricted to the east coast district of the continent, and are now classified as follows:—

A. cordifolia, Cav. (1797)	*A. lanceolata*, Cav. (1797)
A. subvelutina, F.v.M. (1858)	*A. melanoxylon*, R.T.B. (1900)
A. intermedia, DeCandolle (1828)	*A. Bakeri*, Dr. C. Hall (1913)

The first recorded instance of an essential oil from the leaves of any species of Angophora, is the notice in the work by Mr. R. T. Baker and myself "A Research on the

Eucalypts," 1902, p. 16. The leaves of *A. lanceolata* were more easily obtainable, and for this reason were used for the purpose. It was desirable, at that time, to determine whether the oil from this group of Myrtaceous trees was in agreement with that distilled from certain species of Eucalyptus. It had been found previously that the venation of the leaves of some Eucalypts, particularly those of the "Bloodwood" group, indicated the presence of pinene in their oils.[1] The terpene phellandrene is not a constituent of Eucalyptus oils from species so early in the evolution of the genus, and those Eucalypts yielding phellandrene bearing oils have quite a distinct leaf venation.

The venation of the mature lanceolate leaves of the Angophoras is similar to that of the "Bloodwood" group of Eucalypts, and the oils should, therefore, consist largely of pinene. Although the yield of oil from *A. lanceolata* is very small, yet sufficient was obtained to furnish the evidence required, and it was thus possible to show a distinct chemical connection, through their oils, between the Angophoras and the Eucalypts at the older end of that genus. The evidences in other directions, which have accumulated since that time, all tend to support the conclusions then advanced, and it may now be stated with some confidence that the Angophoras are very closely in agreement with the Eucalypts, and that Angophora is the older genus. Besides the evidence derived from the investigation of the oils, this close relation is further emphasised by the study of the kinos, or astringent exudations; and the presence of the caoutchouc on the young leaves of certain species of Angophora and Eucalyptus is also a feature of some value in this connection.

It was desirable, therefore, that an investigation of the oils of all the known species of Angophora in New South

[1] This Journal, Vol. xxxv, p. 116, 1901.

Wales should be undertaken, so that the previous conclusions might be strengthened, or otherwise.

From the results now brought forward it is apparent that the chemical changes which have become such a pronounced feature with the oils of the Eucalypts, had scarcely commenced, if at all, in the oils of the Angophoras. It is possible, however, to trace the origin of certain constituents of Eucalyptus oils, and the dextro-rotatory pinene, the geranyl-acetate, the geraniol, and the sesquiterpene, all had their origin in the oils of the Angophoras, or perhaps in some still older genus. It might be expected that certain constituents would remain persistent in some directions if the suggested relation between the genera was actual as well as apparent. That this is so is shown by the numerous pinene Eucalyptus oils, in which the dextro-rotatory form is such a distinguishing feature, and by the many Eucalyptus oils in which geranyl-acetate occurs, reaching the maximum in that of *Eucalyptus Macarthuri*.

The Angophoras as a class are not promising as oil yielding plants, and from two species, *A. cordifolia* and *subvelutina*, no oil was obtained, while but traces can be distilled from the leaves of *A. intermedia*. Some of the other species, however, give fair yields of oil, more in fact than is obtainable from several species of Eucalyptus.

The following table gives the yields of oil distilled from material cut as would be done for commercial oil distillation:

Angophora	*Bakeri*	0·31 per cent.
,,	*melanoxylon*	0·19 ,,
,,	*sp.*	0·13 ,,
,,	*lanceolata* (Sydney)...	0·013 ,,
,,	*lanceolata* (Warialda)	0·005 ,,
,,	*intermedia*	traces
,,	*subvelutina*	none
,,	*cordifolia*	none

In some instances, over 500 lbs. of leaves and branchlets were distilled.

To test the position of *A. intermedia*, material was obtained both from Penrith, and from near Parramatta. In the latter case no oil was obtainable, while in the former not more than 10 drops of oil were distilled from 120 lbs. of fresh material.

The investigation of the oils thus obtained shows that no marked differences in constituents can be detected between the oils of the several species of Angophora. They all consist largely of dextro-rotatory pinene with a uniformly high specific rotation; two esters of geraniol (geranyl-acetate and geranyl-valerianate), free geraniol, a high boiling constituent, most probably a sesquiterpene; with small amounts of a volatile aldehyde and a low boiling ester, the odour of which was that of amyl-acetate. Neither cineol nor phellandrene were present even in traces. The saponification number for the esters varied somewhat in the several oils, but this factor may be perhaps considered as accidental rather than discriminative, particularly as the pinene in all the oils has practically the same optical activity to the right, and does not vary much in amount.

The general characters of the oils of the Angophoras are thus in close agreement with those distilled from various species of Eucalypts. None of the species of Angophora can be considered of commercial value as oil producing trees, yet the scientific results derived from their investigation are of considerable value in helping to elucidate the problems dealing with the origin and development of the closely related genus Eucalyptus.

The Essential Oils.

Angophora Bakeri.

This species is described in the previous paper, dealing with the seedlings of the Angophoras, by Dr. Cuthbert

Hall. Although the leaves are much smaller and narrower than those of the other species, yet, the venation is similar. The oil glands in the fresh leaves are more pronounced in this species than in the others, and this is also indicated by the greater yield of oil.

Chemistry.—This material was collected in the neighbourhood of Parramatta, in the month of October, and consisted of fresh leaves and terminal branchlets, cut as for commercial oil distillation. The average yield of oil was 0·31 per cent.

The crude oil was light lemon coloured, had an indistinct odour at first, but distinctly a secondary aromatic one. The chief constituents were dextro-rotatory pinene, geraniol, geranyl-acetate, geranyl-valerianate, a small amount of a sesquiterpene, together with a little volatile aldehyde, and most probably a minute quantity of amyl-acetate. No other terpene than pinene was detected and cineol was quite absent. The botanical evidence is also against the presence of either phellandrene or cineol in the oil.

The crude oil had specific gravity at 15° C. = 0·8719; rotation $a_D = + 35°.6$; refractive index at 22° = 1·4660; and was insoluble in 10 volumes 80 per cent. alcohol by weight.

On the rectification of 100 cc. of the oil, a small amount of acid water with some low boiling aldehyde, and a constituent with a pear-like odour, came over below 155° C. (corr.). Between 155 – 160°, 57 per cent. distilled; and between 160 – 172°, 24 per cent. The thermometer then quickly rose to 220°, and between that temperature and 250°, 6 per cent. distilled, with some decomposition. These fractions gave the following results :—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 19° C.
First fraction	0·8658	+ 37°.6	1·4661
Second fraction	0·8689	+ 32°.7	1·4680
Third fraction	0·8995	+ 4°.8	1·4721

72 cc. of the added first two fractions were again distilled, and before 156° C. was passed 50 cc. had distilled (= 50% of the crude oil); and 14 cc. between 156 – 157°. These two fractions gave results closely in agreement, as is seen from the following:—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 19° C.
First fraction	0·8612	+ 37°.5	1·4658
Second fraction	0·8622	+ 36°.6	1·4663

The indications from the above are that the only low boiling terpene present in this oil is pinene, and that over 75 per cent. of the oil of this species consists of that constituent. The odour too, of the terpene was distinctly that of pinene.

The nitrosochloride was prepared with a portion of the first fraction, and this, when finally purified by precipitating by methyl alcohol from a chloroform solution, melted with decomposition at 103 – 104° C., thus confirming the identity of the pinene.

The saponification number for the esters, by boiling, together with that of the free acid, was 33·6. The secondary odour of the separated oil after saponification was that of geraniol, and the presence of geraniol in these oils was proved in that of *A. melanoxylon.* Acetic acid and valerianic acid were also both shown to be present in combination as esters in the oil of that species, and there is no reason to suppose that the esters are different in the oil of *A. Bakeri*, especially as the results of cold saponification in both oils are similar, and as the Angophora oils all resemble each other in constitution.

The saponification number of the ester as determined in the cold, with two hours' contact, was 19·2, so that this portion, calculated as geranyl-acetate, was equal to 6·7 per cent. of that ester, and the remainder calculated as geranyl-valerianate was equal to 6·1 per cent.

A portion of the crude oil was acetylated by boiling one and a half hours with acetic anhydride and anhydrous sodium acetate in the usual way. The saponification number from this was exactly 50. As no other alcohol was detected than geraniol, with the exception, perhaps, of a trace of amyl alcohol as acetate, the amount of free alcohol calculated as geraniol was 4·5 per cent.

The sesquiterpene was only present in small amount in the oil of this species.

The composition of the oil of *Angophora Bakeri* may be stated as follows:—

	Per cent.
Dextro-rotatory pinene ... ... =	78·0
Free geraniol ... ... =	4·5
Geranyl-acetate ... ... =	6·7
Geranyl-valerianate ... ... =	6·1
Water, volatile aldehydes and low-boiling esters =	1·0
Sesquiterpene and undetermined ... ... =	3·7
	100·0

Angophora melanoxylon.

This species was first described by my colleague, Mr. R. T. Baker, F.L.S., in the Proceedings of the Linnean Society of New South Wales, April, 1900.

Chemistry.—This material was collected in the month of March at Coolabah, New South Wales (430 miles west of Sydney), and forwarded to the Museum by Mr. H. T. Morgan, the Public School teacher at that place. It consisted of fresh leaves and terminal branchlets collected as would be done for commercial oil distillation.

CONTENTS.

ISSUED FEBRUARY 5th, 1914

Vol. XLVII. Part II.

JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1913.

PART II., (pp. 113-247).

CONTAINING PAPERS READ IN

AUGUST to DECEMBER.

WITH FIVE PLATES.

(Plates v, vi, vii, viii, ix.)

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH, SYDNEY.
LONDON AGENTS:
GEORGE ROBERTSON & Co., PROPRIETARY LIMITED,
17 WARWICK SQUARE, PATERNOSTER ROW, LONDON, E.C.

1913.

F. WHITE Typ., 344 Kent Street, Sydney.

The average yield of oil was 0·19 per cent. The crude oil was somewhat darker in colour than that of *A. Bakeri*, due to the larger amount of ester and free acid in the oil, the latter more readily attacking the iron of the still. The odour resembled that of *A. Bakeri*, and the aromatic secondary odour was also similar.

The chief constituents in the oil of this species were identical with those in the oil of *A. Bakeri*, although the geranyl-valerianate was a little more pronounced, as was also the sesquiterpene. Phellandrene and cineol were, of course, both absent.

The crude oil had specific gravity at 15° C. = 0.8809; rotation $a_D = + 24°.9$; refractive index at 21°.5 = 1·4678; and was insoluble in 10 volumes 80 per cent. alcohol.

On redistilling 100 cc. of the crude oil, a small amount of acid water, some volatile aldehydes and the constituent with a pear-like odour came over below 155° C. (corr.). Between 155 – 160°, 31 per cent. distilled; and between 160 – 193°, 41 per cent. The thermometer then rose to 225°, and between that temperature and 265°, 20 per cent. distilled, with some decomposition. These fractions gave the following results:—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 20° C.
First fraction	=0·8638	+ 37°.6	1·4630
Second fraction	=0·8648	+ 34°.6	1·4638
Third fraction	=0·9250	too dark	1·4846

The first two fractions were again distilled when 46 per cent. of the whole oil came over to 156° (corr.) and 13 per cent. between 156 – 157°.

These two fractions gave the following results:—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 19° C.
First fraction	=0·8615	+ 37°.9	1·4642
Second fraction	=0·8621	+ 36°.8	1·4644

The above results indicate that the only terpene in the oil is pinene, and that about 70 per cent. of that constituent was present. The nitrosochloride melted at the same temperature as that prepared with the pinene from the oil of *A. Bakeri.*

The saponification number for the esters and free acid in the crude oil by boiling was 42·5, and in the cold with two hours contact 19·8. If the ester broken down by cold saponification be considered to represent the geranyl-acetate, then the result gives 6·93 per cent. of that ester, and 9·64 per cent. geranyl-valerianate. These figures agree very well with those obtained from the ratio of the acids of the esters.

To determine these acids, the third fraction was saponified with alcoholic potash by boiling, water added, the oil separated, and the aqueous portion evaporated to small amount. This was filtered, acidified with sulphuric acid, and steam distilled until the whole of the volatile acids had come over. The distillate was exactly neutralised with barium hydrate solution; evaporated to dryness, the residue powdered and finally heated in air-oven. 0·4197 gram of the barium salt when treated with concentrated sulphuric acid and ignited, gave 0·3195 gram barium sulphate, equal to 76·12 per cent. It was thus evident that a volatile acid of higher molecular weight than acetic acid was present. That the ester containing this acid was in excess was also indicated by the amount saponified in the cold being less than half the total ester. The remainder of the barium salt was then decomposed with dilute sulphuric acid, extracted with ether, and the ether evaporated. The acids which remained gave the characteristic odour of valerianic acid. The acids were but little soluble in water, but the aqueous portion gave reactions for acetic acid. The insoluble portion when heated with a little amylic alcohol

gave an ethereal odour of apples. The reactions thus indicated the presence of acetic and valerianic as the acids of the esters. These acids were thus in combination with the barium as follows:—32·64 per cent. barium acetate, and 67·36 per cent. barium valerianate.

The oil separated after saponification was steam distilled and in the portion which came over, the odour of geraniol was most prominent; the distilled water also had an odour strongly resembling that of rose water. When mildly oxidised with bichromate of potassium in sulphuric acid, the aldehyde citral was readily formed. It thus appears that geraniol is the only alcohol in these esters, and that it is in combination with both acids in the oils of the Angophoras.

A portion of the crude oil was acetylated in the usual way and the saponification of this gave results indicating that 5·1 per cent. of free geraniol was present in the oil of this species.

From the above determinations the composition of the oil of *A. melanoxylon* may be stated as follows:—

	Per cent.
Pinene ... ... =	72·0
Free geraniol ... ... =	5·1
Geranyl acetate ... ... =	6·9
Geranyl valerianate ... ... =	9·6
Water, volatile aldehydes and low-boiling ester =	1·0
Sesquiterpene and undetermined ... ... =	5·4
	100·0

Power and Kleber[1] show geraniol to be present in the oil of Sassafras leaves in combination with both acetic and valerianic acids.

Angophora species.

This species, which grows in the neighbourhood of Bingara, New South Wales, (370 miles north of Sydney), is

[1] Pharm. Review, xiv, p. 103.

considered by my colleague, Mr. R. T. Baker, to be new to science, and it is his intention to describe it before the Linnean Society of this State. As the oil is similar in constitution to those of the other species of Angophora, it may be described here.

Chemistry.—This material was forwarded by the Museum collector from Myall Creek, near Bingara, 370 miles north of Sydney. It was cut as for commercial oil distillation.

The average yield of oil was 0·13 per cent. The crude oil was, in odour and appearance, identical with that of *A. Bakeri.* The chief constituents were also identical with those of that species, with the exception that the pinene was present in greater quantity, and the ester in correspondingly less amount. Phellandrene and cineol were, of course, both absent.

The crude oil had specific gravity at 15° C. = 0·8703; rotation a_D = + 36°.3; refractive index at 20° = 1·4669; and was insoluble in 10 volumes 80 per cent. alcohol.

On the rectification of 100 cc., the usual amount of acid water and volatile aldehydes, together with the constituent of pear-like odour, came over below 155° C. (corr.). Between 155 – 157°, 60 per cent. distilled, and between 157 – 165°, 21 per cent. came over. These fractions gave the following results:—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 17° C.
First fraction	0·8645	+ 37°.9	1·4665
Second fraction	0·8679	+ 37°.3	1·4669

These two mixed fractions were again rectified and the large portion distilling at 156° separated. This had specific gravity at 15° = 0·8618; rotation a_D + 38°.1; and refractive index at 18° = 1·4655. The nitrosochloride melted at the same temperature as those from the pinenes of the other species. The indications are, therefore, that over 80 per

cent. of the oil of this species of Angophora consists of pinene.

The saponification number for the esters and free acids was 18·9, thus showing that the esters were present in somewhat less amount than in the oils of either *A. Bakeri* or *A. melanoxylon.*

ANGOPHORA LANCEOLATA.

This species was described by Cavanilles in 1797. It is a common tree in the neighbourhood of Sydney, and grows principally on the Hawkesbury Sandstone formation. This kind of acid soil is the one it naturally selects by choice, and throughout its wide distribution it still clings to the sandstone. In the district around Warialda, where the low hills are capped with sandstone, this tree is also found growing. It is the only Angophora with a smooth bark; all the others have thick, semi-fibrous, soft barks.

Chemistry.—Material of this species for oil distillation was collected at the Military Reserve, Mosman, Sydney, in the month of June. The yield of oil was very small, equalling only 0·013 per cent. It was a somewhat thick oil and with such a small amount it was difficult to separate. The specific gravity of the crude oil at 15° C. = 0·927; and the refractive index = 1·4946; the oil was insoluble in 10 volumes 80 per cent. alcohol. These results indicate a considerable amount of the sesquiterpene. The saponification number of the esters and free acid by boiling was 24·2; and in the cold with two hours contact 10·1. The secondary odour of the separated saponified oil was that of geraniol, so that judging from the results with the other oils, it may be considered that the geranyl-acetate equalled 3·53 per cent., and the geranyl-valerianate 5·99 per cent.

The available oil was then distilled, and 4 cc. obtained, boiling between 157 - 163° C. (corr.). This had a pinene

odour; specific gravity at 15° = 0·8661; rotation a_D = +33°.8; and refractive index at 16° = 1·4697. The indications are, therefore, for pinene similar in physical properties to that distilled from other species of Angophora, and although the rotation is somewhat less, yet, this is due largely to incomplete rectification, owing to the want of sufficient material.

Material of this species was also procured from Warialda, New South Wales (460 miles north of Sydney). It was forwarded by the Museum Collector in the month of April. The amount of oil was very small, equalling only 0·005 per cent. As such a small quantity of oil was available nothing further was done with it, but it resembled strongly the oil of this species recorded above.

As already stated no oil was obtained from either *A. cordifolia* or *subvelutina*, and only traces from *A. intermedia.*

Summary of Results.

The general results obtained with the crude oils of the three chief oil bearing species of Angophora are here tabulated for means of ready reference.

	Rotation a_D	Sp. gr. at 15°	Ref. index.	S.N. of esters.
A. Bakeri	+35°·6	0·8719	1·4660 at 22°	33·6
A. melanoxylon	+24°·9	0·8809	1·4678 at 21°·5	42·5
A. sp.	+36°·3	0·8703	1·4669 at 20°	18·9

All these oils are insoluble in 10 volumes 80 per cent. alcohol by weight. The differences are but slight when the increased amount of ester in the oil of *A. melanoxylon* and the less amount in the oil of the unamed species are considered.

Little is yet known of the influence which different times of the year may exert on the oils of the Angophoras, although it is not expected that this would influence the results to any great extent.

The finally rectified pinenes of all the species agree very closely in general characters, and this is well shown when the results are tabulated :—

	Rotation a_D	Sp. g. at 15°	Ref. index.	Sp. rota. $[a]_D$
A. Bakeri	+37°·5	0·8612	1·4658 at 18°	+43°·54
A. melanoxylon	+37°·9	0·8615	1·4642 at 19°	+43°·99
A. sp.	+38°·1	0·8618	1·4655 at 18°	+44°·21
A. lanceolata	+33°·8	0·8661	1·4697 at 16°	...

The higher specific gravity, refractive index, and lower rotation of the pinene from *A. lanceolata* is accounted for by the difficulty in sufficiently rectifying the small amount of oil available. There seems, however, no reason to suppose that the physical properties of the fully rectified pinene from this species, would differ from that of the other species.

The essential oils from the oil-yielding species of Angophora are thus seen to be very similar in chemical constituents and in general characters.

I am indebted to my colleague, Mr. R. T. Baker, F.L.S., for the botanical information contained in this paper, and for the authenticity of the material worked upon.

THE PHYSIOGRAPHY OF BOTANY BAY.

By G. H. Halligan, F.G.S.

With Plates V, VI.

[*Read before the Royal Society of N. S. Wales, August 6, 1913.*]

In the many valuable papers that have been written of late years upon the physiography of New South Wales, the subject has been treated entirely from the geologist's standpoint. The earth movements that have undoubtedly taken place have had assigned to them their proper geological age; the vertical displacement of the strata, the effect of the movements upon the direction of the flow of rivers, and the formation of lakes and lagoons consequent upon the folding, faulting and crushing have also been discussed. Though much has been done, it is perhaps needless to say that much remains to be done, but with the enthusiastic band of workers now in the field, we may confidently look for a continuation of the good work in the future.

It is proposed in this paper to deal with that part of the subject which refers to changes in the shore line which have necessarily taken place strictly within Pleistocene and recent times; changes which must be taken into serious consideration by the engineer, as well as the geologist, for it is by a discussion of them that he is enabled to design works in the carrying out of which he will be assisted by nature, and so save the time and money for which he is responsible.

Although this paper is called the physiography of Botany Bay, the principles involved may be taken to apply to many other places along the 600 miles of coast from Point Danger to Gabo Island. Botany Bay has been selected because

of its vicinity to Sydney and the ease with which it may be inspected, and the statements made in this paper verified by any member who cares to spend a short day on this interesting work. A visit to Kurnell and a short walk to the top of the hill near the Trigonometrical Station, "Solander," enables one to obtain a panoramic view of the district described.

It will at once be seen that the dominant feature is the very large area of sand which fringes the shore line on the northern, western and southern sides of the bay, and extends inland as shown by the stippled area on the accompanying map (Plate V). The edge of the sand furthest from the existing shore-line shows approximately the boundary of the old rocky coast of Trias-Jura sandstone, possibly at the time the last subsidence, of from 200 to 300 feet, took place.[1]

In this paper an attempt is made to solve the problem of how all this sand came here, and why the shore-line has assumed its existing shape.

There are two streams discharging into Botany Bay, viz:—George's River, having a length of 50 miles, and Cook's River, which is about 11 miles long. The combined catchment area of the two rivers is 339 square miles.

The course of George's River for the upper 30 miles is through steep rocky gorges in the familiar Hawkesbury sandstone formation. Highwater level of the ocean is reached about the township of Liverpool, at which point a dam was erected about the year 1830 for the purpose of obtaining a water supply for the residents. It will thus be manifest that any sand coming down George's River will be deposited fn the bed of the stream where the gradient of the river ceases, and before any sand can arrive at

[1] David, T. W. E., B.A., D.SC., F.R.S., Anniversary Address to the Royal Society of New South Wales, May 1896, this Journal, Vol. xxx, p. 57.

Botany Bay nearly the whole of the stream-bed from Liverpool to the mouth must be filled, and this as we know is far from being the case. That a large amount of sediment is being deposited can be readily seen just below the Liverpool Dam. At this spot the old steamer "Phantom" which drew about eight feet used to ply with coal for the Liverpool residents until about forty years ago. This part of the river is now so sanded up that one can walk across it in places almost dry footed at low tide. Several other places lower down the stream also shows signs of sand accumulation due to floods, but the total quantity, although large enough to seriously interfere with navigation, is insignificant when compared with the enormous deposits on the shores of Botany Bay.

The total length of Cook's River is about 11 miles, and from its source to the point where it meets the highwater level of the ocean, is four and a half miles. The catchment area, which is almost wholly in Wianamatta shale country, naturally does not produce much sand, the flats at Marrickville and Tempe being composed of hard mud. Dams are erected at Canterbury, about six and a half miles, and at Tempe which is about three miles from the mouth, and at neither place is any sand accumulation visible.

Quite apart from other considerations, it will thus be seen that the sand in Botany Bay could not have been deposited in its present position by the waters of George's and Cook's Rivers.

First, because the quantity now visible, which has been brought down during historic times, is so insignificant that countless ages would be necessary to account for the enormous accumulation at Botany Bay, and neither the growth of timber nor the depth of humus on the sand flats referred to, indicates the lapse of any such very lengthy period.

Second, all borings taken on the stippled area shown on the maps show clean white sand from the present shore-line to the original highwater mark, and this obviously could not have been carried down the rivers during flood time, for, had it been so carried, traces of alluvium would appear, and the flats would consist of good soil in place of the present hungry sand, which supports only the hardiest vegetation.

Third, the disposition of the sand is not such as would indicate the deposits of sluggish streams in salt water, as will presently be shown.

In this the author is at variance with the views expressed in a paper recently presented to this Society[1] in which it is stated that this accumulation of sand is due to the "enormous amount of silting accomplished by the action of George's and Cook's Rivers when in flood."

It is obvious that the sandy deposits in any estuary must be due to one of two causes. Either they must have been brought down from the watershed area of the inflowing rivers during floods, or they must have come in from the sea shore by the action of currents. If the sand comes from the uplands it will be mixed with alluvium and will tend to form flats more or less muddy, and such flats do not exist on the shores of Botany Bay except near the mouth of George's River. In this particular locality, the mud is due to the flood waters of the river depositing its small load of alluvium, washed down from the hills in the immediate vicinity, where the current is checked by meeting the still waters of the bay. The deposit is comparatively small and is largely mixed with sea sand.

It now remains to be shown how the sand, indicated by the stippled area on Plate V, was brought in from the sea,

[1] E. C. Andrews, B.A., F.G.S., "Beach Formations at Botany Bay," this Journal, Vol. XLVI, p. 163.

why it assumed its present form, and what is going on in the way of sand movement at the present time.

Plate VI shows the general trend of the ocean currents on the Australian coast, compiled from the latest reports and charts of the British Admiralty. A very large number of observations by the author, of the southerly current on the New South Wales coast, show it to have a mean velocity of from one to two nautical miles per hour from the shore line to at least twenty miles out. This velocity varies very little with the seasons. The surface water is accelerated by the north-easterly winds in the summer, and slightly retarded by the strong southerly winds at other seasons, but such puny forces must be practically ineffectual on a stream many hundreds of feet deep, many miles in width, and thousands of miles long.

At all the salient points on the coast, from the Tweed River to Jervis Bay, the littoral current is flowing to the southward all the year round, and is conveying sand in suspension in large quantities.[1] When this current meets with an obstruction in the form of an island, a vortex is formed on the lee side, and the sand is here deposited in the form technically known as a banner reef. The land now known as Kurnell, the historic landing place of Captain Cook, was originally such an island, and the sand accumulated on the south-western or lee side of it until it joined the main land again at Cronulla. The sand having been brought in by the currents was heaped up by the wind into dunes varying from 20 – 130 feet in height, thus closing up the southern outlet of Botany Bay, and completing the first stage in the filling-up process of this area.

---

[1] G. H. Halligan, F.G.S., "Sand Movement on the Coast of New South Wales," Proc. Linn. Soc. N.S.W., 1906; also "The Bar Harbours of New South Wales," Min. and Proc. Inst. C.E., Vols. CLXXXIV and CLXXXV.

In another paper[2] it has been shown that, with the existing rise and fall of tide on the New South Wales coast, a ratio of at least one foot width of entrance to four acres of tidal compartment in any estuary, is necessary in order that the velocity of the flood tide at the entrance shall be less than the velocity of the ocean current. When such exist, no sand is brought into the estuary, but is all conveyed past in the littoral current.

When the ratio is greater than four acres to one foot, sand is carried in, the amount varying as the velocity of the current necessary to fill the larger area. At present the area of the tidal compartment of Botany Bay is 14,246 acres, and the least width of entrance is 3,467 feet, the ratio being 1 : 4.11, and very little sand is at present entering the bay. In proof of this the soundings taken by the author in 1910, as compared with those taken by Captain Cook in 1770, show no general shoaling of the bay.

In years gone by however, when the waters of the bay occupied the stippled area on the western and northern side of the existing bay, the area was twice the present size, and consequently the current velocity of the tide at the entrance was about twice the present speed. Large quantities of sand were thus carried into the estuary and deposited in the still water along the eastern shore of the bay. The largest quantity of sand, would, of course, be carried in during times of strong southerly gales when the ocean current was to a certain extent retarded, and the difference between its speed and that of the flood tide was greatest. The southerly winds at the same time would tend to create a northerly current in the still waters of the bay, thus help to convey the sand to the northern end where Centennial Park and Randwick Racecourse now

[2] G. H. Halligan, "Bar Harbours of New South Wales," Min. and Proc. Inst. of C.E., Vol. CLXXXIV, p. 144.

exist. As time went on, and the sand accumulated on the area now known as the Botany Swamps, the sun dried the surface sand and the winds heaped it into dunes, the rain water filled the hollows, and the floods maintained a tortuous channel from lagoon to lagoon. In latter years dams were erected across this channel and the water impounded in them was used for many years as the sole source of supply for the City of Sydney.

The patches of black, indurated sand occasionally met with on this area, are the result of many years of growth and decay of aquatic plants on the swampy areas between the dunes. The carbonaceous soil thus formed consolidated, under pressure of the sand blown in from the surrounding dunes to fill up the old swamp, into the familiar indurated black sand which is to be found on similarly formed country from Queensland to Twofold Bay.[1]

As the northern part of the area referred to became filled up, the ratio between the area of the tidal compartment and the entrance width became less and the area of still water decreased. The southerly and south-easterly winds still created surface currents in the bay sufficient to convey the sand brought in by the flood tide to the area now known as Sans Souci and Sandringham, but as the amount of sand brought in became less, the rate of filling up has steadily decreased and, at the present time, only a very small amount of sand is moving in Botany Bay below high water.

The direction of the movement may be clearly seen at the Long Pier near the Botany Tramway Sheds. At this point the sand has heaped up against the stone approach to the Jetty on the eastern side, and has left the beach

---

[1] For further information on the subject of the origin of these indurated sand beds see J. E. Carne, F.G.S., Annual Report, Dept. of Mines, 1895, pp. 149 – 160.

completely denuded of sand on the western side. There are also evidences of this westerly movement of the sand at Cook's River entrance, but at Long Pier the direction of the sand travel, on this side of the bay, is unmistakable.

At Sans Souci the beach sand is slowly being moved towards Kogarah Bay by the flood tide into George's River, as shown by comparative soundings taken in recent years, but the movement is not pronounced enough to be visible to the casual observer. If George's River did not exist, this sand would be conveyed eastwards to Quibray Bay and Weeney Bay, both of which would long ago have been filled up. At present they are slowly being filled by blown sand from the Cronulla dunes, which, in the first part of this paper, were referred to as being built upon the banner reef which was formed between the old island of Kurnell and the mainland.

The author sees no reason to call in positive earth movement or negative movement of the ocean to account for the high sand ridges and dunes met with on this or any other portion of the New South Wales coast. The wind action may be noted any day, and the various and fantastic forms assumed by the moving sand may be plainly seen, on a small scale, on any sandy shore, to agree with the formation due to years of continued exposure to all sorts of wind and weather.

The author would like to call attention here to the so-called *dominant wind* so often referred to, with reference to sand movement. There is no such thing as dominant wind as applied to any but a very small area at one time. What is a dominant wind at Bondi cannot be so called at Manly Beach, nor can the wind which has most influence on sand dune formation at the north shore of Botany Bay have any effect at all on the sand movement on the southern shore. It is therefore not correct to refer to the dominant

wind over areas of any large extent. On a steep hillside sloping to the north-east, the strong north-easterly winds in summer will bend the growing timber towards the south-west, and will cause all the well-known tree deformation common on wind swept slopes. On the other side of the hill, where the land slopes to the south, the winds from that quarter will similarly affect the growth of timber on the hill side which the north-easters do not touch. In this case, the so-called dominant wind would be from the north-east on one slope of the hill, and south-west on the other.

As regards sand movement above high water, the movement must, on this coast, as a general rule, be to the northward, as the winds, having a velocity sufficient to move sand in any quantity (say 20 miles per hour and over) blow much more frequently from southerly than from northerly directions,[1] the proportion being 1 to 1·78, during a period of ten years.

Whatever wind happens to be most effective over a certain area will heap the sand into dunes; small obstructions will form eddies, which prevent the ridges assuming a regular form; lengthy periods of ample rainfall will produce luxuriant growth of reeds in parts where water accumulates, and these in turn die and rot away to form humus, which other and less hardy plants may grow in. It is nothing unusual to find sand dunes in other parts of the world of from 100 to 300 feet high, and although dunes of varying heights will be found within a short distance of one another, there is generally a noticeable uniformity in the height on each beach.

This is due to the uniformity in the duration of the particular wind which is mainly responsible for the dunes, over the particular area, and should not, in the opinion of the author, be taken to indicate earth movement unless

[1] "Sand Movement on the Coast of New South Wales," *Ibid.*, p. 625.

some very positive evidence is available in the neighbourhood to substantiate the supposition.

In the neighbourhood of Botany Bay there has been no very definite evidence of elevation in Pleistocene times yet discovered, nor does there appear to the author to be any reason for assuming it, unless the actions we see going on around us every day should be insufficient to account for the phenomena of the past.

NOTES ON THE RECTIFYING PROPERTY IN SILICON AND SELENIUM.

By O. U. VONWILLER, B.Sc.,
Assistant-Professor of Physics in the University of Sydney.

[*Read before the Royal Society of N. S. Wales, September 3, 1913.*]

SOME time ago when working with a selenium cell consisting of a thin sheet of conducting selenium extending between two parallel platinum wires, two millimetres apart, the writer observed that the conductance apparently varied with the direction in which the current passed. As is usually the case with selenium cells, Ohm's law did not hold, but instead of the conductance rising, it was found that for one direction of the current the conductance decreased at first as the e.m.f. was increased, rising for higher values. When the current passed in the opposite direction the conductance rose as the e.m.f. increased from the lowest values. The minimum value of the conductance was obtained for an e.m.f. of about one volt and was 0·97 of the value for zero voltage. For an e.m.f. of two volts the current in one direction was ten per cent. greater than

that in the other. When the cell was illuminated by an 8 c.p. lamp at a distance of 100 cms. similar relationships were observed, the conductance being in all cases almost exactly 1·3 times as great as when in the dark.

An examination of the cell showed that one of the two platinum wires had become detached from the selenium over more than half its length; when the current entered the selenium by this wire smaller conductance was obtained.

Further experiments were carried out in which there was a much greater difference between the areas of the two surfaces of contact between metal and selenium, and it was found that in most cases a distinct rectifying property was to be detected. The best results were obtained when the current passed between one of the platinum wires of a cell, such as that mentioned before, and a needle or thin platinum wire of which the end rested lightly on the selenium. The rectifying power varied greatly, depending largely on the pressure between the point and the selenium; as the pressure was increased the conductance increased, and the rectifying property decreased to a marked extent, disappearing for comparatively small pressures. The greatest ratio obtained for the currents for any e.m.f. was about 40 to 1.

Curve I in fig. 1 shows the variation of current with e.m.f. for each direction of flow between one of the wires of the cell described above, and a fine platinum wire the end of which rested lightly on the selenium. The abscissæ represent the e.m.f's. applied (0·2 volt being taken as the unit) while the currents are represented, on an arbitrary scale, by the ordinates. In this, as in all other cases to be mentioned, the positive values represent those obtained when the current flowed from the metal surface of smaller to that of larger area.

Whenever the rectification was great the resistance was extremely high, and the currents could not be measured to a high degree of accuracy as the observations become very irregular when the currents were increased, this being due in all probability to heating effects. Instead of thin sheets, large masses of selenium were sometimes used, and with these the rectifying property was observed when the current entered and left through surfaces of unequal area, but the differences were not so great as those sometimes obtained with thin sheets.

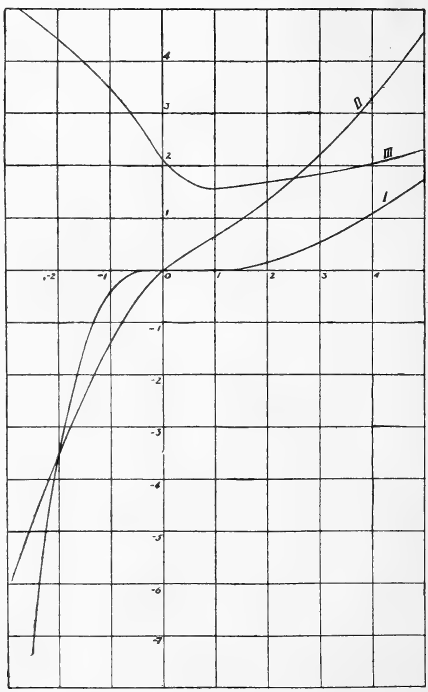
In all cases the current for any e.m.f. was less when the point was at the higher potential than when at the lower potential, and in a number of trials the conductance fell at first when the e.m.f. was increased, the flow being in the positive direction. In some experiments the currents were too small to permit the existence of the minimum to be detected; when it occurred it was for an e.m.f. of not more than one volt.

Several trials were made with alternating electro-motive forces of frequencies varying from 20 to 60, the currents being measured with an Einthoven galvanometer which enabled the maximum value of the current to be observed for each direction. The effects were similar to those obtained with continuous currents; for example, on one occasion, a deflection in one direction of 3·5 divisions was obtained before a movement of one tenth of a division was detected on the other side, so that the substance must take up the condition necessary that rectification may occur within a very short time of the application of the e.m.f.

It seemed to be of interest to ascertain whether other substances of the many which possess the rectifying property showed a minimum conductance such as that found with selenium, and some experiments were carried out with silicon. In all the trials with this material the conductance

was apparently greater when the current flowed in a negative direction, that is when it entered the silicon through the surface of greater area. The conductivity is much greater than that of selenium, so that it was possible to obtain accurate readings of the currents for very small differences of potential. On many occasions evidence of a minimum conductance for a small positive e.m.f. was obtained.

Fig. 1.



Curve II, fig. 1, shows the relation between current and e.m.f. in a case when a piece of silicon, roughly pyramidal in form, was held between two brass plates, one at the base and one at the apex; the height of the pyramid was $2\frac{1}{2}$ centimetres. The change of direction of curvature does not occur at the origin but some distance on the positive

side of it. This is shown to a more marked extent by Curve III, which gives the apparent conductances (that is, the ratio of current to e.m.f.) as ordinates, the abscissæ representing values of the e.m.f. as in the other curves. In Curve II the unit of e.m.f. is $\frac{4}{15}$ volt and the unit of current $\frac{1}{750}$ ampere; for higher values than those shown the rectification becomes greater.

Several curves similar to those shown were obtained, the form being the same under various conditions and with various metals making contact with the silicon; steel, brass, copper and platinum were used for one or both surfaces in different trials. The position of the minimum varied on different occasions, but the e.m.f. at the point of minimum conductance was always less than one volt.

With the object of obtaining further information about the minimum conductance, some trials were made in which two steel needles or two copper wires with rounded ends were pressed against the piece of silicon, held as described above, at points about one millimetre from the brass plates. The difference of potential between any two of the four metal contact pieces, namely the two brass plates and the two wires or needles, could be determined by means of a potentiometer and the value of the current measured by observing the difference of potential between the ends of a standard resistance coil joined in series with the silicon.

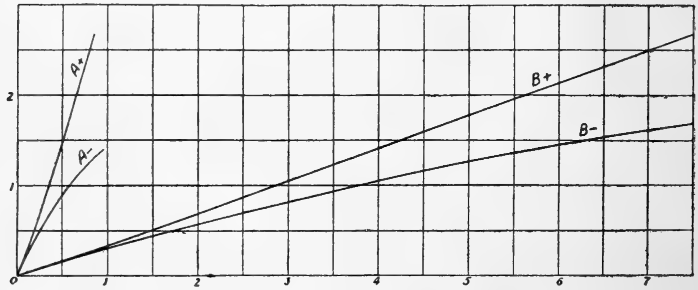
It was found that the difference of potential between the brass plate at the apex of the pyramid and the contact wire one millimetre from it was always much greater than the difference at the base, and that between the two contact wires was but a small fraction of either, so that the actual resistance of the silicon was very small compared with the contact resistances.

Both at the base and apex it was found that, when the current flowed from the brass to the silicon, the difference

of potential across the junction was greater than when the direction of flow was reversed, and when observations were made with very small currents it was found that when the current flowed from brass to silicon the difference of potential across the junction increased relatively more rapidly than the current; for larger currents, the reverse was the case, and when the current flowed from silicon to brass the difference of potential across the surface always increased relatively at a less rate than the current.

In figure 2 are given curves showing the relation between currents (abscissæ) and the differences of potential across the surfaces of contact (ordinates); the unit of current is 0·001 ampere, and of potential difference, 0·1 volt. A+ represents the difference of potential at the apex when the current flows into the silicon at that place, A− representing the case of a flow in the opposite direction. B+ and B− represent the differences of potential at the base, B+ being the case when the current enters, and B− that when it leaves at the base.

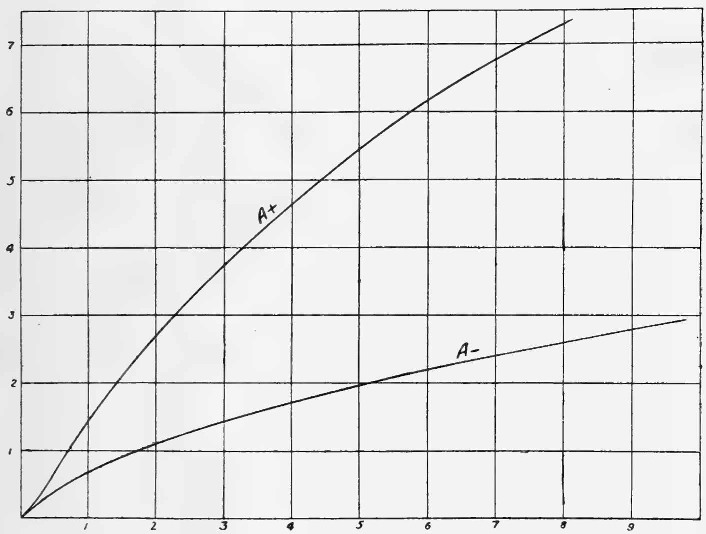
Fig. 2.



In the case of both A+ and B+ the curves are at first concave upwards; A− and B− are convex upwards throughout. With higher values of current all the curves are convex upwards; in figure 3 are given observations for A+ and A−, readings being taken for much higher values

of current than those given in figure 2. In the case of A+ the change of curvature is quite plainly seen. In this figure the unit of current is 0·0009 ampere, and the unit difference of potential 0·18 volt. By adding the ordinates of A+ and B−, and A− and B+, a current voltage curve similar to that of Curve II, fig. 1, is obtained, (allowing for the change of axes), the potential drop in the silicon itself being negligible compared with that across the junctions. The presence of the apparent minimum conductance on the positive side is due to the form of the A+ curve.

Fig. 3.



Similar curves were obtained on several occasions with the aid of the potentiometer, and also when a gold leaf electrometer was employed in the measurement of the differences of potential.

It seems natural to associate the phenomena observed with the absorption or evolution of heat which occurs when currents cross junctions of different metals. The Peltier effect with silicon is very great, the thermo-electric height

being, according to Miss Frances Wick, (Phys. Rev. 1907), about 400 micro-volts at ordinary temperatures; the only substances for which it is numerically greater are tellurium and selenium. The result of the passage of a current across a metal-silicon junction is a cooling or heating at that point, and this in turn gives rise to an e.m.f. opposing the flow of current—an e.m.f. proportional to the current. On account of the differences in area the temperature change, and therefore the potential difference, must be greater at the surface of smaller area. The rectifying property apparently can be explained by the action of the Thomson effect if we assume that for small currents the main bulk of the silicon is not appreciably altered in temperature, but that the heated or cooled portions are limited to thin layers in close proximity to the junctions. In such a case the additional absorption or evolution of heat due to the flow between points at different temperatures is limited to the boundary layers, and the Thomson effect being the same at both junctions, while the Peltier effect is opposite, we see that at one junction a summational effect, and at the other a differential heating effect, should ensue, so that at either junction the opposing e.m.f. should depend on the direction of the current.

An investigation on these lines shows that the relation between the back e.m.f. and current should be of the form $e = ai \pm bi^2$. The actual observations show that this is very approximately the form of the relation obtained for small currents.

Great, however, as are the thermo-electric effects with the materials here dealt with, the results obtained are such that differences in temperature of very many degrees must occur in order satisfactorily to explain the results obtained and it seems that the above explanation is not correct.

The curves A+ and B+ resemble the current voltage curve obtained by Dr. W. H. Eccles (Phil. Mag., June 1910), when a current passed through a film of iron oxide between a point and plate. In this case the curve obtained was the same for each direction of current, and the form of the curve is shown by Dr. Eccles to be consistent with the view that the passage of the current heats the film and decreases its resistance, the resistance temperature coefficient of the film being negative.

If in the case of silicon the presence of a surface film of some different material or structure is the cause of the phenomena observed, its nature must depend upon the direction of the current—possibly its formation may depend upon the flow of the current—as the effects observed differ to such a marked extent when the direction of the current is reversed. With silicon the resistance of the main body of the material was always very small in comparison with the contact resistances, but with selenium cells of the ordinary type the contact resistance is usually a relatively small fraction of the total resistance.

THE IONISATION CAUSED BY PENETRATING γ RAYS IN A CLOSED THICK-WALLED VESSEL.

By S. E. PEIRCE, B.Sc.,

Deas-Thomson Scholar in Physics in the University of Sydney.

(Communicated by Professor Pollock)

[*Read before the Royal Society of N. S. Wales, September 3, 1913.*]

THIS research is an extension of some experiments described by Professor Bragg,[1] in a paper on "The Consequences of the Corpuscular Hypothesis of the γ and X Rays, and the Range of the β Rays," in connection with the discussion of the ionisation caused by penetrating γ rays in a closed thick-walled vessel in terms of his corpuscular theory.

According to this theory when a stream of γ rays crosses a block of any material some of the γ particles are lost to the stream by conversion into β rays through collision with atoms. Each γ ray of given quality is converted into a β ray of a definite initial velocity, irrespective of the substance in which the change takes place. The number of β rays formed in unit volume of the material will thus be proportional to the coefficient of absorption (k) of the γ rays per unit mass, and the average intensity (I) of the γ rays in that volume.

The β rays thus formed, to continue Professor Bragg's argument, are deflected by collision with atoms and lose energy from the same cause, the average loss of energy at a collision varying with the nature of the material only. This loss of energy finally brings the electrons to rest.

The total distance which a β particle travels in any material will not vary much, for β rays of given initial

---

[1] Bragg, Phil. Mag., S. 6, Vol. xx, p. 385, 1910, also "Studies in Radioactivity," p. 94.

velocity, from an average value which will be inversely proportional to the average loss of energy per collision, and to the density of the material. If the range (d) of the β ray in a given material is defined, in terms of the mass of metal traversed, as the mass of a cylinder whose axis is the straightened path of the ray divided by its cross section, a quantity is obtained which is independent of the density (ρ) of the material.

If the γ rays have the same intensity everywhere in a block of any material, the sum of all the tracks completed in a unit volume per second will be proportional to the number of β rays formed in that volume ($Ik\rho$) and to the distance the β ray travels (d/ρ) and is quite defined by the product Ikd. This quantity depends only on the nature of the material, not on its homogeneity or density.

Any cavity in the substance does not alter the value of Ikd anywhere within the boundaries of the material including the cavity itself, since every β ray must cross a mass d of the substance and crossing the cavity does not count in this. If air is now introduced into the cavity the value of kd in the cavity will not be altered unless the energy of the β rays is appreciably absorbed in crossing the chamber, and the value of kd for air is much different from that for the material surrounding it.

The ionisation produced in the cavity per unit volume will be proportional to the sum of all the paths of the β rays completed within unit volume. This sum has just been shown to be proportional to Ikd; if, therefore, an ionisation chamber is prepared with walls thick enough to prevent any β rays formed on the inside from penetrating to the outside, and with an air chamber so small that no appreciable amount of β ray energy is absorbed in crossing the chamber at the pressure of gas employed, then the ionisation will give a measure of Ikd for the substance of which the chamber is composed.

To get relative values of *kd* for different substances it is necessary to prepare ionisation vessels of similar shape but of different materials. Following Professor Bragg's method, values relative to that for lead have been obtained by comparing the ionisation in a lead cylinder, due to a stream of γ rays from some radium bromide placed beneath it, with ionisations under similar conditions when the cylinder was completely lined with other metals.

The lead cylinder is 15 cm. long and 9·6 cm. in internal radius. It is closed with lead plates of the same thickness as that of the cylinder (0·5 cm.). The linings are made of the same form to fit closely inside the lead chamber. The top plates both of the lead and of the linings are provided with a hole to admit the copper wire electrode. This is supported axially in the chamber by a plug of sulphur in which is embedded an earthed guard ring.

A battery of small storage cells is attached to the lead cylinder raising its potential to about 400 volts, which was found to be sufficient to saturate the largest current obtained. The axial electrode is connected to a key by means of which it may be joined to earth and thence to one pair of quadrants of a Dolezalek electrometer, the other pair being earthed. The electrode is also connected to the inside cylinder of a cylindrical condenser, of which the outer coating is attached to a variable source of potential. By varying the potential of the outer cylinder the inner cylinder and its connections may be kept at zero potential while they are receiving a charge from the ionisation chamber. The current in the ionisation chamber will then be proportional to the rate at which the potential on the outside cylinder is altered.

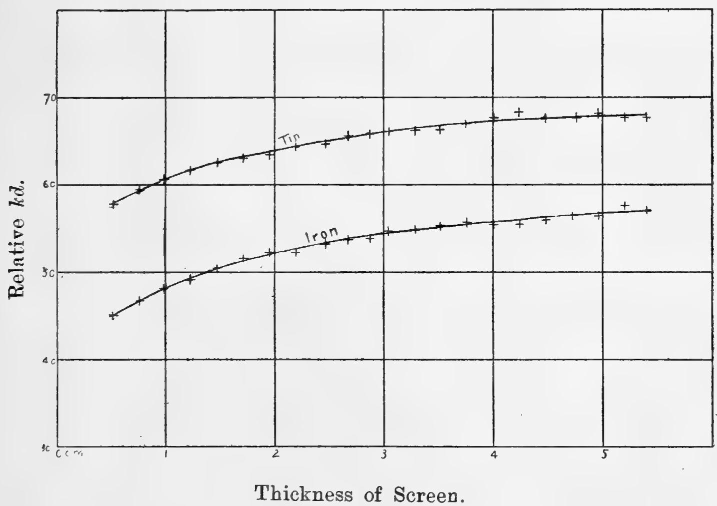
In order to vary the potential of the outer cylinder of the condenser it was connected to a sliding contact on a potentiometer wire wound helically on an ebonite drum.

Suitable gearing, worked by a handle, was arranged so that the contact piece could be moved along the wire at a rate which was easily varied. One end of the wire was earthed.

In measuring the ionisation current, the electrode was disconnected from earth and the handle turned so as to keep the needle of the electrometer at its zero position. The time was taken by a stop-watch from the instant at which the electrode was disconnected to the instant at which the electrometer needle began to move after the sliding contact had moved through a definite difference of potential. The reciprocal of this time gave a measure of the ionisation current in arbitrary units.

To obtain values of *kd* relative to that of lead in the case of any metal, the ionisation in the lead chamber is compared with that in the chamber lined with the given metal. In this latter case the γ rays pass through a greater thickness of material than with the unlined cylinder before emerging into the chamber, so that the intensity of the rays is not the same in the two chambers. To ensure the

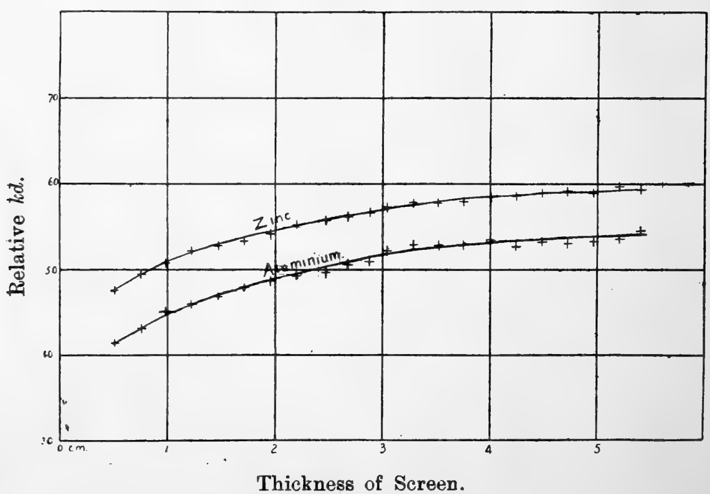
Fig. 1.



same intensity of rays in both cases, when the ionisation in the unlined cylinder is being measured, the bottom plate of the lining to be afterwards used is placed as a screen between the radium bromide and the lead cylinder. The ratio of the two ionisation currents, taken in this way, corrected for the differences in volume of the air and for the natural leak in the chambers, gives the value of the *kd* of the material of the lining relative to that of lead.

Values of the product *kd* have been obtained by this method for the metals tin, copper, zinc, iron, and aluminium and also for a card cylinder. The source of γ rays was 5 mg. of radium bromide placed on the axis of the lead cylinder 20 cm. below its base. Experiments were first made to find out whether varying the distance of the radium from the cylinder along its axis had any effect. No difference was found except when the radium was screened with thick screens and was put close to the base of the cylinder. In this case an increase in the observed relative *kd* of the metal was found. Now when the radium is close

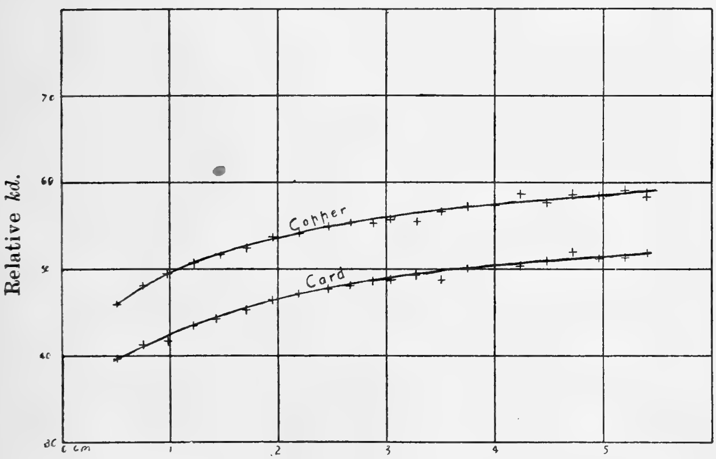
Fig. 2.



to the cylinder a greater number of the γ rays more oblique to the axis of the cylinder get in. These rays have to traverse a greater distance in the screen and so have their quality changed more than the rays parallel to the axis. The effect of screening the γ rays is to increase the *kd* in any substance relative to lead; the increase in the relative *kd* when the radium is close to the cylinder is not more than could be accounted for by this fact.

In these experiments the radium was screened with various thicknesses of lead from 0·5 centimetres, (the thickness of the base of the lead cylinder), to 5·4 centimetres, by steps of about 0·25 centimetres. The curves, in figures 1, 2 and 3, show the relation between the *kd* and the thickness of the screen for the substances enumerated above. The increase in the value of *kd*, as the thickness of the screen becomes greater, is attributed by Professor Bragg to a change in the value for the lead only. An inspection of the curves shows that the full change has not taken place with the thickest screen employed, 5·4 centi-

Fig. 3.



Thickness of Screen.

metres. Diminishing the thickness of the linings, which was originally about 0·3 centimetres, had no effect on the values of *kd*, so the thickness was sufficient in all cases to give the true value.

In the following table the relative values of *kd* for the minimum and maximum screenings are compared with those given by Professor Bragg.

Substance.	At. mass.	ρ	*kd.* Thickness of screen 0·47 cm. Bragg.		Thickness of screen 1·57 cm. Bragg.		Thickness of screen 5·4 cm.	$\frac{kd}{\rho}$
Lead ...	207·1	11·37	100	100	100	100	100	8·8
Tin	119·0	7·29	58	58	68	63	68	9·3
Zinc ...	65·4	7·1	47	47·5	55	55·3	59·5	8·4
Copper ...	63·6	8·93	...	46	..	52	59	6·7
Iron ...	55·9	7·86	45	45	54	51	57	7·3
Aluminium	27·1	2·65	40	41·5	49	47·5	54	20·4
Card ..	12±	0·9 ±	39	39·5	46	45	52	50+

In the last column of the above table are given the values of *kd* for the maximum screening divided by the density of the material. If it is assumed that *k* is the same for the different metals, the numbers represent the relative lengths of path of the β rays in the various substances.

EXTRACTION OF RADIUM FROM THE OLARY ORES.

By S. Radcliff.

[*Read before the Royal Society of N. S. Wales, October 1, 1913.*]

Introduction.

In May of the year 1906 a prospector forwarded some pieces of a dense dark coloured mineral, carrying small amounts of a yellow incrustation in the surface crevices, to Adelaide for examination. Mr. W. S. Chapman, the Government Assayer, identified the yellow substance as carnotite, a vanadate of uranium and potassium. He found the material to contain 60 per cent. of uranium oxide and a considerable amount of vanadic oxide.

The locality from which the ore was obtained was shortly afterwards visited by Mr. H. Y. L. Brown, then Government Geologist of South Australia. He stated: "The ore occurs as yellow and greenish-yellow incrustations and powder on the faces, joints, and cavities of a lode formation, which consists of magnetic titaniferous iron, magnetite, etc., and quartz in association with black mica[1] (biotite).

Dr. Mawson subsequently published an account of a mineralogical examination of the lode-stuff and came to the conclusion that it contained several new minerals.[2]

Some years later a block of the ore, weighing about 16lbs., was forwarded to the Imperial Institute. A detailed mineralogical and chemical examination was there made of the material by Messrs. T. Crook and G. S. Blake.[3]

---

[1] Record of Mines of S. Australia, 4th edition, Adelaide, 1908, p. 361.

[2] D. Mawson, Trans. Roy. Soc. S. Aust. 1906, Vol. xxx, p. 188.

[3] D. Crook, F.G.S., G. S. Blake, D.SC., F.C.S., Mineralogical Mag. March 1910, Vol. xv, No. 77, pp. 271–284.

Some typical specimens of the ore were I understand, forwarded to Madame Curie; she reported that the ore was only feebly radioactive and of little commercial value, radium at that time being comparatively cheap.

In 1909 a company known as the Radium Hill Company was formed in Sydney to exploit the deposit commercially, and a consignment of about 30 tons of picked ore was taken to England by Dr. Mawson, who brought it under the notice of a number of firms, both in England and on the Continent, interested in the extraction of radium from its ores. A few tons were also sent to America. The low uranium content and the high percentage of titanium present, which rendered treatment difficult, militated against the disposal of the ore, and no offers of any value were received for it.

While these negotiations were in progress, the author of this paper (who, some time prior to the Olary find had discovered a radioactive copper ore at Moonta, S.A.) was asked to investigate the possibility of treating the ore locally; and after some twelve months' experimental work developed a process which gave promise of commercial success. The preliminary work was done at the Bairnsdale School of Mines, Victoria, which possesses a fairly extensive metallurgical plant, a total quantity of 30 tons being dealt with in the course of the experiments. From the data so obtained the plant now in successful operation at Woolwich on the Parramatta River, Sydney, was designed.

The present communication gives a preliminary account of the treatment process as it is worked at the present time.

The most complete account yet given of the extraction of radium from its ores is that by Haitinger and Ulrich.[1]

---

[1] Haitinger and Ulrich, Sitz Ber. der Wiener Akad. IIa Bd. 117 (1908) pp. 619 – 630.

They describe the methods adopted by them in treating 10 tons of residues derived from about 30 tons of pitchblende ore containing 54·2 per cent. of U_3O_8. The treatment of the ten tons occupied two years, and resulted in the recovery of three grams of radium chloride in a state approaching purity. No analyses are given in this paper and only very scanty details as to the plant used.

As these residues were derived from ore containing 270 milligrams of radium (calculated as bromide) per ton, and as the Olary ore, even when concentrated, contains only eight milligrams, it is obvious that any process to be commercially successful when applied to these latter ores must be comparatively simple in operation, and must allow of a considerable tonnage being put through annually. It may be noted that eight milligrams of bromide to the ton means one part in 125 million or one part of elementary radium in 214 million parts of concentrates.

As first observed by H. Y. L. Brown the amount of visible carnotite in the ore is negligible from an economic point of view, and for practical purposes the ore consists of a mixture of ilmenite, magnetite, and rutile, with small amounts of carnotite and a mineral stated by Crook and Blake to be probably tcheffkinite. Table I gives:—

(*a*) Analysis of the ore complex excluding the carnotite, taken from Crook and Blake's paper.

(*b*) Analysis of the concentrates now being treated at Woolwich.

(*c*) Analysis of a typical Austrian pitchblende.[1]

Table I.

	a	*b*	*c*
Lime	0·25	0·55	2·55
Lead oxide	0·4	0·16	1·9
Ferric oxide	17·87	17·4	1·14

[1] Brearly, Analytical Chemistry of Uranium, p. 43.

	a	*b*	*c*
Ferrous oxide	17·37	16·9	...
Manganous oxide	0·24	trace	0·11
Thorium oxide	0·13		
Cerium oxide	1·26	4·68	
Lanthanum and didymium oxide	2·13	3·27	
Yttrium oxide	1·16		
Chromium sesquioxide	1·6	0·85	
Uranoso uranic oxide	2·25	1·6	49·95
Vanadic oxide	0·93	0·86	0·02
Titanium dioxide...	51·85	45·85	
Silica	1·15	12·70	18·54
Zinc oxide...	...	...	... 1·09
Phosphoric oxide...	...	...	... 0·33
Sulphur	...	...	... 5·08
Arsenic	...	...	... 0·44
Bismuth	...	...	... 0·24
Copper	...	...	... 0·89
Iron	...	...	... 8·04
Carbon dioxide	...	...	... 5·02

The ore is dry crushed at the mine to pass a sieve of 20 holes to the linear inch, and is then concentrated magnetically; the concentrates, amounting to about 30 per cent. of the ore crushed being forwarded to Sydney for treatment.

One of the most interesting points about analysis (*a*) is that the ratio of the uranium to the thorium is as 16·7 : 1; radium preparations worked up from this ore should therefore contain very little mesothorium. This conclusion has been confirmed in Rutherford's laboratory by Dr. Alexander Russell who examined a specimen of the bromide and found it to contain as radio-active substances only radium and its decomposition products.

As the concentrates are insoluble in acids, a fusion process is necessary to effect the initial decomposition. The

concentrates are mixed with three times their weight of salt cake (acid sulphate of soda) and fused in a reverberatory furnace of sufficient capacity to take 500 kilos of concentrates and 1500 of salt cake in a single charge. Three charges can be put through in twenty-four hours. The fused product, crushed to pass a sieve of eight holes to the linear inch, is fed, in small amounts at a time, into wooden vats fitted with agitators. Cold water is fed continuously into the vats at the bottom and an overflow is provided near the top. By suitably adjusting the conditions, it is possible to separate out on the bottoms of the vats a considerable amount of comparatively coarse material which is almost free from radium and uranium. The turbid liquid overflowing carries in suspension the radium lead and barium as sulphates, together with a considerable amount of finely divided silica; while in solution we have the uranium rare earths, and part of the iron and acid earths contained in the ore.

The coarse residues are removed from the vats daily, re-washed to free them from any undissolved fused product and sent to the dump. The composition of these residues is given in Table III.

The overflow from the dissolving vats is pumped to large lead-lined settling tanks and allowed to stand all night. The "slimes" settle completely in twelve hours, and the clear liquid is drawn off daily and treated for the recovery of the uranium. The slimes which amount, when dried, to approximately 10 per cent. of the weight of the concentrates, are collected weekly and treated for the recovery of the radium as described below.

The further steps in the treatment process may conveniently be described under two heads:—

(*a*) The recovery of the uranium.

(*b*) The recovery of the radium.

(a) **Recovery of the Uranium.**

The clear solution containing the uranium and much of the iron and other bases in the concentrates, together with a large amount of sodium salts, is fed into a series of vats containing a measured excess of a mixture of carbonate and bicarbonate of soda; and heated and agitated by means of steam jets. The iron, with most of the other bases present is precipitated, while the uranium goes into solution together with some of the rare earths. The bulky iron precipitate is separated partly by settlement and partly by means of vacuum filters. It is difficult to handle and cannot be washed effectually, a portion of the uranium is therefore unavoidably discarded along with this precipitate. The uranium solution is made just acid with sulphuric acid, heated, and the carbon dioxide expelled by a brisk current of air. The uranium is then precipitated by the addition of ammonia. The ammonium uranate is thickened somewhat in conical settling tanks and then further thickened to a pulp in a hydro extractor. This pulp is dried and dehydrated in large muffles. The dehydrated product is broken up and washed repeatedly with hot water. This treatment removes the bulk of the sodium salts, and a product is obtained which on drying contains about 75 per cent. of U_3O_8. An analysis of this, together with that of the iron precipitate, is given in Table II. Prior to analysis the iron hydroxide was twice dissolved and re-precipitated with ammonia to free it from the large amount of sodium salts present. The washed precipitate was dried, ignited and analysed.

Table II.

	Uranium Product.	Iron Precipitate.
Insoluble matter	3·0	...
Titanium dioxide	...	8·11
Ferric oxide	9·41	74·65
Uranoso uranic oxide	76·6	2·7

	Uranium Product.	Iron Precipitate
Rare earths	1·57	7·36
Lead oxide	0·51	...
Vanadic oxide	...	1·2
Chromium oxide	...	5·81
Sodium salts	8·21	...

(b) **Recovery of the Radium.**

The thickened insoluble residue or slime from the settling tank is mixed with half its dry weight of strong sulphuric acid and allowed to stand for several days. It is then washed, first by decantation and then on a vacuum filter, till the washings give only a very slight precipitate with barium chloride. The acid treatment and washing reduces the bulk of the slime considerably, removing large amounts of acid earths and iron salts. The washed slime in quantities of about 200 kilos, dry weight, is then boiled in large steel boilers with an excess of a 20 per cent. solution of sodium carbonate for two days, the solution being replaced once during the boiling. This treatment dissolves a large amount of silica, and converts much of the lead, radium and barium sulphates to carbonates. The slime is then washed till the wash water gives no reaction for sulphates; this takes two days for each lot of 200 kilos. The washed slime is then fed into a warm dilute solution of hydrochloric acid, agitated for a couple of hours, and allowed to settle all night. The clear solution is siphoned off and the lead, barium and radium precipitated as sulphates. After washing once by decantation, the slime is again treated as above described. Two treatments suffice to extract most of the radium, but the slime is reserved for a further treatment if necessary. The plant as at present arranged, can treat the slime from ten tons of concentrates per week. The weekly yield of crude sulphate is about 12 kilos.

During the past two years I have made a number of experiments, both in the laboratory and on the working

scale, to see if the sulphates in the slime could be reduced by heating the material with carbonaceous substances, or else in a current of some reducing gas, but the results so far have not been encouraging.

The crude sulphate is fused with carbonate of soda in large graphite pots, and the product digested with hot water. The insoluble residue after picking out most of the metallic lead is thoroughly washed, and heated with hydrochloric acid. The solution is evaporated to dryness to dehydrate the silica, the residue moistened with acid and digested with hot water and the silica filtered off.

It was found that the method of converting the sulphates to carbonates by boiling with concentrated soda solution was altogether too slow, and the fusion method has the further advantage of removing most of the lead in the metallic state. This lead which is, of course, radio-active (Table IV) is being stored for examination later. The hydrochloric acid solution, containing the radium and barium, together with large amounts of lead, iron, and acid earths, was formerly treated by the ordinary analytical methods for the removal of the impurities prior to precipitating the radium and barium as carbonates. Bulky precipitates, difficult to handle and wash were obtained; this procedure has been abandoned, and a method due to Soddy[1] is now used with very satisfactory results.

The chloride solution is saturated with hydrogen chloride and the barium and radium are thrown down nearly free from other elements. The crystalline precipitate is filtered off, freed by suction from most of the adhering liquid and dried. It is dissolved in water, the small amounts of lead, iron, etc., still remaining, removed, and the mixed carbonates of barium and radium finally dissolved in hydrobromic acid for fractionation. About 1500 grams of dry chloride,

---

[1] F. Soddy, Chemistry of Radio Elements, p. 45.

which when freed from radio-active substances other than radium has an equilibrium activity of from 40 to 50, are obtained weekly.

Table III gives analysis of the slime, of the tailings or coarse residues, and of the crude sulphate. The whole series of operations is summarised in the accompanying flow sheet.

Table III.

	Crude Sulphates.	Slimes.	Tailings.
Silica	10·82	51·42	22
Titanium dioxide ...	3·0	42·40	63·1
Ferric oxide	2·15	4·21	14·23
Rare earths	...	...	0·41
Uranoso uranic oxide	...	...	...
Lead sulphate... ...	69·24	1·85	trace
Barium sulphate ...	12·50	0·23	...

The composition of the tailings is of great interest, the high percentage of titanium dioxide being noteworthy. It is apparent that the initial fusion effects a selective decomposition of the ore complex, the uranium minerals are completely decomposed, and the tailings, which contain a large proportion of comparatively coarse grains, seem to consist largely of unaltered rutile.

Repeated assays of the tailings have failed to detect appreciable amounts of uranium. As will be seen too, from Table IV, the amount of radium left in the tailings must be very small.

The economic success of the process apparently depends on the fact that it is only necessary to partly decompose the ore mixture in the fusion furnace, and that therefore, comparatively small amounts of reagents are required. If it had been necessary to completely decompose the ore in order to extract the radium, treatment costs would I think, under local conditions at least, have been prohibitive. As

a matter of fact, about 50 per cent. of the concentrates consist of minerals almost free from radium and uranium, this being the proportion of the material fused sent to the dump each week.

An approximately ten-fold concentration of the radium is therefore effected by the two simple operations of fusing the concentrates and dissolving the fused product under proper conditions.

In Table IV the relative activities per unit mass of the concentrates, tailings and slimes are given.

Table IV.

	Activity per unit mass.
Uranium oxide	1·0
Tailings	0·007
Concentrates	0·06
Slimes	0·25
Crude sulphate	11·0

The radio-active lead separated out on smelting the sulphate has an activity approximately twice that of uranium oxide when three months old.

The whole of the radium in the concentrates must distribute itself between the tailings and the slimes. As the tailings amount to five times the weight of the slimes, it appears from the relative activities of the two products that 86 per cent of the radium contents of the ore is concentrated in the slimes, 14 per cent. being rejected in the tailings.

So far I have done nothing in the separation of the other radio-active bodies in the ore. I hope, however, to examine a portion of the radio-active lead now being stored very shortly, as its activity appears too high to be wholly due to radium D and its products. Rutherford[1] states that "radium D is separated with the large amount of lead

[1] E. Rutherford, The Radio-active Substances, p. 511.

usually present in radio-active minerals. In the course of time, radium D produces radium F (polonium) and the ray activity of the lead becomes about equal to that of uranium."

As stated previously, the radio lead separated on smelting the crude sulphide was about twice this activity. It is possible that this is due to small amounts of radium barium sulphate included in the lead. The lead accumulated in the course of several years will ultimately form a convenient source for the working up of polonium preparations. As the amount of polonium in equilibrium with a mineral containing one grain of radium is only 0·19 milligram, the direct recovery of polonium from the working solution is obviously out of the question.

It should be possible on the other hand to work up fairly active ionium preparations from the rare earths without much difficulty.

While the chief technical problems in connection with this ore may be regarded as solved, much work of a scientific character remains to be done, and I hope to continue investigations on the three following lines:—

1. To make a complete spectrographic examination of the ore and the various products separated out during treatment.

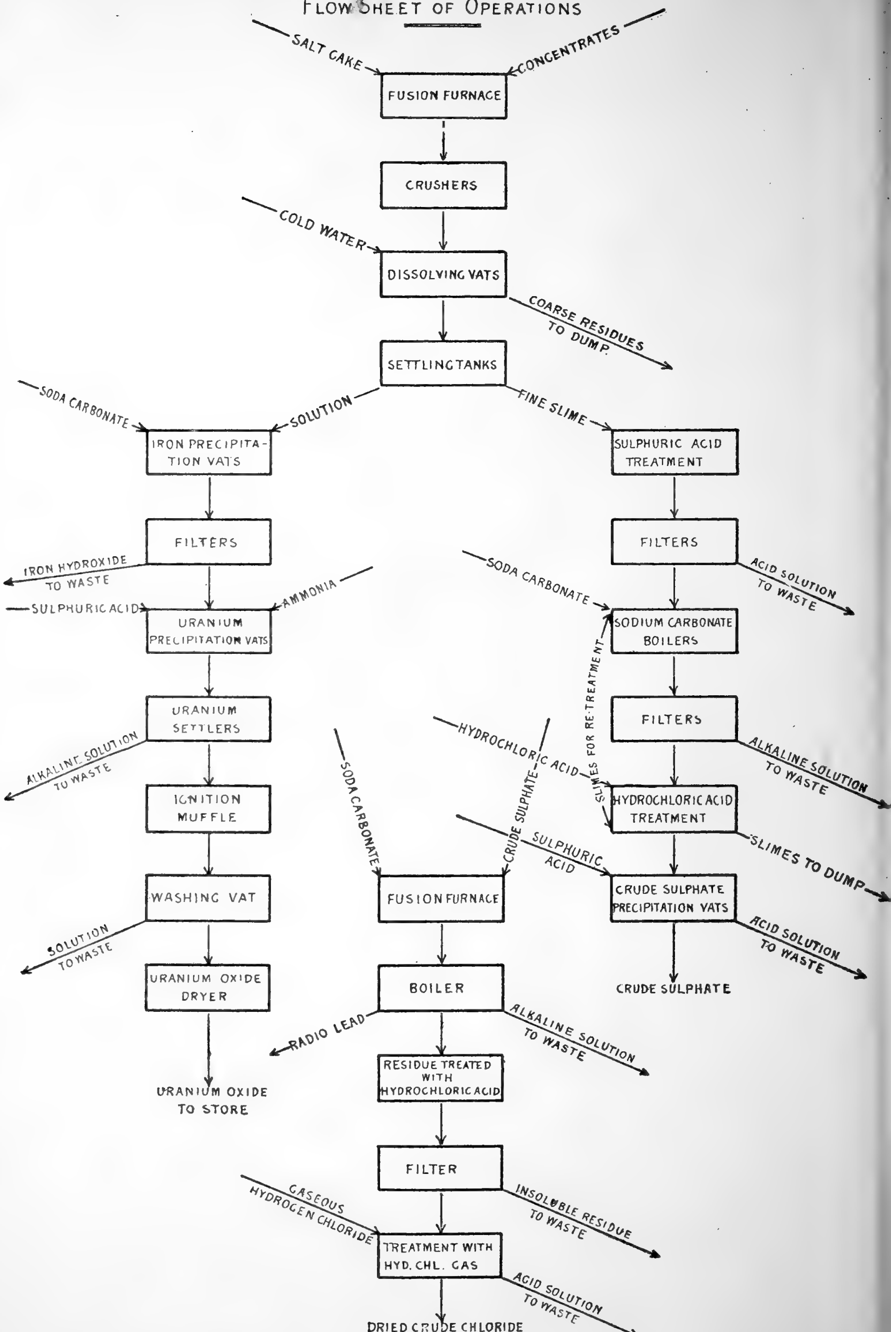
2. To investigate the radio-active properties of these products.

3. To work up some kilos of the rare earths in order to examine them in detail.

In conclusion I desire to thank Professor Pollock for his kindness in testing various radium preparations from time to time, and for the friendly interest he has taken in the work throughout.

Radium Extraction Process

Flow Sheet of Operations



VANILLA: AND A SHORT AND SIMPLE METHOD FOR THE DETERMINATION OF VANILLIN.

By W. M. DOHERTY, F.I.C., F.C.S.

With Plate VII.

[*Read before the Royal Society of N. S. Wales, October 1, 1913.*]

IN all civilised countries vanilla is known and used, either alone or blended, as a perfume or as a flavouring substance in food, confectionery, and the like, and although there are persons to whom its flavour and odour are unpleasant, it has managed to worm its way into almost every household, and rare indeed is the domicile which does not know it some time in the year. It is of much interest to the organic chemist, inasmuch as the artificial elaboration of vanillin, the aromatic aldehyde to which vanilla owes its characteristic odour, is one of the early successes of synthesis. So great was the value put upon this substance that in the year of its artificial production, namely 1876, its price was no less than £160 per pound avoirdupois. This price gradually decreased, and now it can be purchased for a tenth of that number of shillings. The high price I have quoted, is an indication of the value of the vanilla pods from which previously the vanillin had been prepared, and the reduction in cost shows well how great has been the success of the chemists.

To the analyst also, who has to investigate certain preparations into the menstruum of which vanilla extractives should enter, there is much food for thought. Indeed a pulling to pieces of the concoctions which in days before the Pure Food Act came into force used to pass muster as the genuine article, was a matter for serious application. I have known mixtures of benzoic acid, coumarin, helio-

tropin and vanillin to be blended together quite free from any sign of vanilla beans. But generally speaking, more costly preparations are the rule now (for the true vanilla is still high in price), although there are indications that some manufacturers fortify an inferior natural product with the cheap, though in itself excellent, artificial vanillin. In this paper I propose to describe a simple process for the determination of vanillin in genuine essences, and, incidently, to give a brief account of the vanilla plant itself.

But before passing to this, I would like to say a little concerning a phase of the subject which is of some importance. It has been affirmed that the vanillin alone is the only valuable part of vanilla, and the employment of the whole pod in making an essence is an expensive application of an old-fashioned custom to no good purpose, besides it disregards the advance of science, as applied to this article. Now I do not think that vanillin alone, although it goes a long way towards it, is an absolute substitute for vanilla, any more than synthetic acetic acid is a substitute for malt vinegar, or, if I am not unduly stretching the analogy, morphia a substitute for opium, or strychnine for nux vomica. It is a very significant fact, and well worth emphasising in this connection, that vanilla grown and cured in Mexico, which is the only natural home of the vanilla of commerce, is still by far the most highly prized, although it may contain actually less vanillin than the same species grown and cured elsewhere. Such competent observers as Leach, Parry, Allen, and Tibble support this view. The latter in his "Foods: their origin, manufacture and composition," p. 738, makes the following pregnant statement:—

"It is considered, however, that the fine aroma and fragrance is not due to vanillin alone. The interior of the fruit contains vanillic acid, resins 4 per cent., fat 11 per cent., sugar 10 per

cent., gum, etc., the whole forming a balsam which is insoluble in water but readily extracted by alcohol. The gums, resins and oil probably contribute to the flavour and aroma, for it has been observed that the finest fruit contains the least vanillin. The unripe beans are said to contain coniferin and two enzymes—one enzyme converts coniferin into coniferyl alcohol, the other into vanillic aldehyde."

I may add, by the way, that the glucoside coniferin, obtained from the cambium of Coniferæ, was the substance originally used by Tieman in the preparation of artificial vanillin, the coniferin being decomposed by boiling with dilute acids into glucose and coniferyl alcohol, which body yielded vanillin on oxidation.

There are fifty species of vanilla, (Orchidaceæ), but only one is used commercially to any extent, and that one is *V. planifolia*, a native of Mexico. The true home of this species, and where it still flourishes in its wild state, is a narrow strip 50 miles wide and 90 miles long, 5 miles in from the shores of Campeachy Bay. The upper end of this strip is about 50 miles south of Tampico and extends along the coast 90 miles towards the city of Vera Cruz.

It has been used from time immemorial by the Toltecs and later by the Aztecs who called it Tlilxochitl. They used it chiefly to flavour their chocolatl, or chocolate. It was as such flavouring that Cortes first became acquainted with it, but he introduced it into Europe as a perfume in the year 1519. Later on it began to be used in medicine as a gentle stimulant and promoter of digestion, and in large doses it was said to act as a powerful aphrodisiac.

It has been introduced into Reunion, Ceylon, Seychelles, Mauritius, Java, Tahiti, and Fiji, and fruits well in these places if artificially fertilised; for its native Mexico is the only land where fertilisation appears to be carried on effectively by Nature's agencies alone. Mexican beans are still

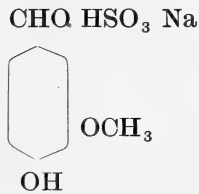
regarded as the best, securing the highest price,[1] and though they are not necessarily the richest in vanillin, they contain an adequate amount, averaging about 2 per cent. The Java and Bourbon beans have yielded as much as 2·75 per cent. to 2·9 per cent. respectively. Some Tahiti beans, which I have lately examined, have been very deficient, yielding only from 0·6 to 0·7 per cent. This low yield was a source of much trouble to some of the local manufacturers of vanilla essence who used this inferior fruit, and thus produced an article very deficient in the chief essential.

Ordinary good essence of vanilla should contain at least the soluble content of one pound of the fruit in one gallon of menstruum. If the beans are of normal quality, the essence will contain about 0·2 per cent. of vanillin.

For the determination of the vanillin in essences of vanilla I have tried several processes, and consider that which makes use of the aldehyde reaction with bisulphite to be most reliable, although it is somewhat lengthy. (In the presence of such bodies as coumarin or benzoic acid it leaves nothing to be desired). My modification of the process with essence of vanilla is as follows:—Fifty cubic centimetres are distilled, the distillate being utilised in the determination of the alcoholic strength, and in the determination of volatilised vanillin which it invariably contains. The residue is acidified and extracted in a continuous extraction apparatus, shown in Plate VII, or exhausted in the ordinary way, four times with ether. The ether which contains the whole of the vanillin, less the small amount which came over in the alcoholic distillate, is removed by evaporation or distillation from the residual vanillin, etc., until only about three cubic centimetres remain. This is treated with twenty cubic centimetres of

[1] Bourbon beans have lately been sold in Sydney for 20s. per pound.

a ten per cent. aqueous solution of sodium bisulphite and after shaking and contact for at least an hour, at ordinary temperature, is well washed with ether. This ether is treated with a further five cubic centimetres of the bisulphite solution, and after separation may be washed and evaporated and the residue examined for the presence of foreign substances such as coumarin, the active principle of the Tonkin Bean, benzoic acid, acetanilide, etc. The bisulphite solution is added to the main portion, which is then acidified with dilute sulphuric acid, and this must be added in sufficient quantity to decompose the bisulphite and so set free the aldehyde. The bisulphite compound may be thus shown:—



It will be seen that one molecule of vanillin (molecular weight 152) requires one molecule of sodium bisulphite (molecular weight 104), and as 2·5 grammes of the salt are used it follows from the known reaction between sulphuric acid and bisulphite that at least an equal weight of sulphuric acid should be added, but this should not be greatly in excess. The sulphurous acid produced in the reaction may be eliminated from the solution by passing carbon dioxide through it. The vanillin is then extracted with chloroform using twenty cubic centimetres, fifteen cubic centimetres, and ten cubic centimetres successively. The chloroform solutions are combined and washed twice with distilled water to free them from acid, and allowed to spontaneously evaporate. The wash waters are added to the chloroform-extracted acid liquor, and this is separately extracted with ether, which is evaporated, and whatever

residue of vanillin there may be left is added to the alcoholic distillate at first obtained. The residue from the chloroform, which contains practically the whole of the vanillin after drying in a vacuum over $CaCl_2$ is weighed in a tared dish. If properly carried out the resultant vanillin is generally pure enough, though at times it may contain some impurity, and may even contain a foreign aldehydic body such as heliotropin. The melting point should be taken and a known portion dissolved in alcohol and compared colorimetrically with a standard solution of pure vanillin, using the reaction occasioned by bromine water and ferrous sulphate. This colorimetric comparison which I am about to describe may be used in determining the amount of vanillin in the alcoholic distillate before mentioned. Vanillin, I may state, can be accurately titrated in alcoholic solution, phenol phthalein being the indicator, one cubic centimetre of decinormal solution being equal to 0·0152 gramme of vanillin.

When vanillin is treated in a dilute solution with bromine water and ferrous sulphate (ammonium-ferrous sulphate may also be used), a green colour is produced which is proportional in its density to the quantity present. This fact is the basis of an American official method which employs a cream of lead hydroxide to decolorise the essence. I have never been able to obtain uniform results with this method as described, and have long since rejected the use of the lead compound, retaining, however, the bromine and the iron salt. I carry out the method as follows:—

One cubic centimetre of the sample is treated in a small separator with ten cubic centimetres, and then with five cubic centimetres of ether, which on separation is allowed to evaporate in a warm place on about thirty cubic centimetres of distilled water. When all the ether has evaporated, the watery solution is filtered through a moistened

filter to the fifty cubic centimetres mark in a Nessler glass. Ten drops of a freshly prepared saturated solution of bromine water and ten drops of a ten per cent. solution of ferrous sulphate are added in the order mentioned. The colour is compared with a 0·2 per cent. solution of pure vanillin (tested by titration with decinormal alcoholic potash), either by simple nesslerising or, preferably, with a Duboscq colorimeter. This process is very simple and expeditious, and if carried out carefully, so accurate, that I feel assured it will prove a boon to those whose business it is to standardise vanilla essences. It may be further simplified by adding the bromine and iron solution to the diluted essence, using one cubic centimetre to fifty cubic centimetres of water, comparing with a similar essence whose vanillin content is known.

The extraction apparatus shown in Plate VII, is an application of the continuous automatic principle found in the Soxhlet tube, designed for the extraction of liquid, and has been improvised from forms which are usually found in all chemical laboratories. It should be noted that the siphon tube should extend to about half an inch above the liquid to be extracted, and be turned upwards at the end. The size of the separator may be varied to suit the quantity of liquid operated on. Though no originality is claimed for the central idea of this apparatus, I have not seen it elsewhere in the form described.

A FLAME TEST FOR CHLORAL HYDRATE.

By W. M. Doherty, F.I.C., F.C.S.

[*Read before the Royal Society of N. S. Wales, October 1, 1913.*]

I have frequently observed that when chloroform was being evaporated, the flames of the brass Bunsen burners

in the immediate vicinity, especially those with a "rose," became coloured more or less intensely green, and if the quantity of chloroform was large, electric blue. This coloration was due to the volatile chloride of copper formed from the metal of the burner itself, and the chlorine, one of the products of the decomposition of the chloroform, or tri-chloromethane. I found that if the "rose" of the burner was cleaned so as to expose the metal, and if the flame was carefully adjusted to a certain point, it was possible to detect extremely small quantities of chloroform in relatively large quantities of water by simply putting the mouth of the bottle containing the liquid in juxtaposition with the air orifice of the burner.

An improvement of the test is in the use of a type of spectrum burner, designed for the detection of boric acid, which answers admirably, provided a piece of clean copper wire (not too thin or it will melt) is placed in such a position on the burner as to be outside the inner cone of the flame. If a solution containing one drop of chloroform to 100 cubic centimetres of water, after shaking well, be placed in the glass arm attachment of the burner a distinctly green flame is produced. Any volatile halogen compound will, however, give the colour, for example hydrochloric acid, though it is not nearly as active as chloroform. Applied as a test for chloral hydrate it was found most satisfactory. If a solution of this substance be placed in the glass portion of the spectrum burner previously mentioned, there is no coloration of the flame. Immediately on adding caustic alkali, the flame becomes coloured with an intensity depending upon the amount of chloral hydrate present, the effect being produced by the well known reaction:—

$$CCl_3CHO + NaOH = CCl_3H + NaCHO_2$$

ON SOME TRANSVERSE TESTS OF AUSTRALIAN AND FOREIGN TIMBERS.

By JAMES NANGLE, F.R.A.S.,

Acting Superintendent, Technical Education, Sydney.

[*Read before the Royal Society of N. S. Wales, October 1, 1913.*]

I. Introduction.

As our Australian timbers are coming more and more into vogue for such purposes as railway carriage construction, carriage building, and other classes of work, enquiries are continually being received for data in regard to their relative strengths. It will therefore be likely that the results of some tests made at the Sydney Technical College under my supervision will be of value. For comparison, foreign timbers have also been tested and the results appended. The timbers used in this investigation are with one or two exceptions, well known or just coming into the market, as *Eucalyptus delegatensis* and *E. amygdalina.*

II. Botany and Remarks on Individual Timbers.

I am indebted to Mr. R. T. Baker, Curator of the Technological Museum, for the botanical names of the specimens. The New South Wales timbers are from logs obtained by the Museum collectors from time to time, and the names are founded on botanical material collected with each tree and now preserved in the Museum Herbarium for future reference and comparison.

In nearly every instance three specimens were taken, so that the results might give a fair average of the respective timbers. In one or two instances, such as the "Grey" or "White Ironbark," it is difficult to account for the apparent discrepancies, as the conditions of seasoning, testing, etc.,

were the same, and yet this wood gave the highest figures of any—10,000 lbs. as breaking load in pounds, and as low as 6,750 lbs. In some cases there must have been a latent defect, for it is difficult to explain otherwise how a splendid timber like *E. rostrata* (Murray Red Gum), could show such extremes as 5,000 lbs. and 2,230 lbs. Some timbers on the other hand, show a good uniformity of figures, such as "Karri," "Blackwood," etc.

It is gratifying to find a despised timber, such as *E. amygdalina*, coming out so well in these tests, the maximum breaking load giving well over 7,000 lbs. Such a result justifies the uses to which this timber has recently been employed in carriage and coach work, and in oars, sculls, and furniture making. The same remarks also apply to *Eucalyptus delegatensis*, which is now largely used for furniture under the name of "Oak"—a timber it much resembles when utilised in the cabinet industry.

"Axe-breaker" (Crow's-foot Elm)—a name applied by timber getters to *Tarrietia argyrodendron*, well deserves the appellation, as the breaking strain equals that of "Teak" and some "Ironbarks," and is equal also to "Blackbutt," *E. pilularis*, or "Spotted Gum," *E. maculata*, and fulfils the reputation it has earned as a good all-round timber, as shown by the figures here given.

Then, again, some of the Eucalypts gave poor results, such as *E. nova-anglica* and *E. Bridgesiana*, whilst nearly all the non-Eucalypts and non-Conifers show good average breaking qualities. In the group of Pines or Conifers, "Hoop Pine," "Maryborough Pine" or "Colonial Pine" and "Celery-top Pine," are the best, the figures being very satisfactory.

From the results there can be no doubt that many avenues of utility yet remain to the technologist in the employment of our native timbers.

The foreign timbers tested are those mostly found on the Sydney market to-day, and the results should be useful for comparison with the local article.

III. Description of Apparatus used in making the Tests.

The specimens tested were 3″ × 3″ in cross section, and 37″ long. These were measured in cross section to ·01 of an inch, and were tested on a span of 36″ in the 25 ton Olsen screw power testing machine in the Technical College Testing Laboratory. The deflections were observed with a deflectometer consisting of a straight edge resting on pins placed in the neutral layer of the test specimens at points just over the bearings. The errors due to crushing of the fibres at the bearings were thus eliminated. By means of a pointed lever working at the centre of the deflectometer, the deflections were magnified, so that it was possible to read to ·001 of an inch without difficulty. Mr. A. H. Martin gave great assistance with the testing and reduction of the observations.

IV. Tabulated Results.

Species in botanical sequence.

Botanical Name. (Common Name.)	Breaking Load in Pounds.	Modulus of rupture in lbs. per sq. inch.	Modulus of elasticity in lbs. per square inch.	Rate of Load in lbs. per minute.
N.O. Sterculiaceæ.				
1. *Tarrietia argyrodendron* ... (Crow's Foot Elm)	8,000	18,060	...	727
2. do. do. ...	7,400	14,473	...	493
3. do. do. ...	8,000	14,348	...	800
N.O. Meliaceæ.				
1. *Flindersia australis* ... (Colonial Teak)	6,320	13,253	2,549,610	742
2. do. do. ...	8,000		...	...
1. *Flindersia Chatawaiana* ... (Queensland Maple)	5,985	14,267	1,379,087	427
2. do. do. ...	6,050	11,427	2,068,631	504
1. ——— ... ... (Mararie)	7,790	15,580	2,584,615	556
2. do. do. ...	7,540	14,685	2,767,205	580
3. do. do. ...	8,345	14,502	2,272,207	642

TABULATED RESULTS—Continued.

Botanical Name. (Common Name.)	Breaking Load in Pounds.	Modulus of rupture in lbs. per sq. inch.	Modulus of elasticity in lbs. per square inch.	Rate of Load in lbs. per minute.
N.O. LEGUMINOSÆ.				
1. *Acacia melanoxylon* ... (Blackwood)	6,500	12,701	...	722
2. do. do. ...	6,500	12,504	...	650
3. do. do. ...	6,000	11,960	...	600
N.O. SAXIFRAGEÆ.				
1. *Ceratopetalum apetalum* ... (Coachwood)	6,325	13,386	1,938,830	421·6
2. do. do. ...	5,825	12,288	2,059,819	448
3. do. do. ...	6,430	14,392	2,042,051	494·6
4. do. do. ...	6,670	14,149	1,996,964	606·3
N.O. MYRTACEÆ.				
1. *Eucalyptus amygdalina* ... (Messmate)	7,600	12,857	2,160,000	428
1. *Eucalyptus Andrewsi* .. (New England Peppermint)	4,960	9,920	1,440,000	708
2. do. do. ...	4,990	9,849	1,578,947	623·7
3. do. do. ...	4,660	9,382	1,322,269	665·7
1. *Eucalyptus Bridgesiana* ... (Woolly Butt)	5,510	11,363	...	423
2. do. do. ...	4,570	9,282	1,189,762	457
3. do. do. ...	3,490	8,244	1,658,880	426
4. do. do. ...	4,160	8,604	1,183,163	520
1. *Eucalyptus campanulata* ... (Stringy Bark)	6,585	13,347	2,070,646	506·5
1. *Eucalyptus delegatensis* ... (Mountain Ash)	4,415	9,675	1,920,290	490
2. do. do. ...	4,180	9,097	1,533,263	321
3. do do. ...	6,000	15,254	1,986,206	461
1. *Eucalyptus laevopinea* ... (Silvertop Stringy Bark)	5,750	11,199	1,383,902	638
2. do. do. ...	4,750	9,312	1,270,590	678
3. do. do. ...	5,050	9,900	1,246,428	505
1. *Eucalyptus macrorrhyncha* (Red Stringy Bark)	6,340	12,980	...	452
2. do. do. ...	6,160	12,654	...	684
3. do. do. ...	5,610	11,651	...	623
4. do. do. ...	5,500	11,109	...	785
1. *Eucalyptus maculata* ... (Spotted Gum)	7,000	14,736	2,977,413	777
2. do. do. ...	7,300	14,897	2,618,181	811
3. do. do. ...	7,450	15,623	2,567,547	931

TABULATED RESULTS—Continued.

Botanical Name. (Common Name.)	Breaking Load in Pounds.	Modulus of rupture in lbs. per sq. inch.	Modulus of elasticity in lbs. per square inch.	Rate of Load in lbs. per minute.
1. *Eucalyptus marginata* ... (Jarrah)	5,500	9,667	1,524,706	785
2. do. do. ...	5,850	8,796	1,080,000	731
3. do. do. ...	5,650	9,313	1,209,958	807
4. do. do. ...	7,140	14,280	2,240,000	892
5. do. do. ...	5,720	11,440	2,666,666	817
1. *Eucalyptus microcorys* ... (Tallow Wood)	6,500	13,310	2,430,000	722
2. do. do. ...	6,000	12,385	2,803,846	644
3. do. do. ...	8,000	16,210	3,294,117	800
1. *Eucalyptus nova-Anglica* ... (Broad Suckered Peppermint)	3,750	7,500	1,234,285	312
2. do. do. ...	4,850	9,897	4,785,233	404
3. do. do. ...	4,400	9,295	...	440
1. *Eucalyptus obliqua* ... (Stringy Bark)	5,850	12,187	2,650,909	731
2. do. do. ...	6,600	13,750	3,836,842	733
3, do. do. ...	6,510	13,166	3,029,610	813
1. *Eucalyptus paniculata* ... (White or Grey Ironbark)	9,850	19,700	3,716,129	829
2. do. do. ...	10,000	23,245	...	...
3. do. do. ...	8,910	17,820	3,456,000	891
1. do. do. ...	7,800	16,848	2,419,200	1114
3. do. do. ...	6,750	14,435	2,434,226	843
1. *Eucalyptus pilularis* ... (Blackbutt)	8,000	16,161	3,557,647	800
2. do. do. ...	8,450	16,200	3,251,612	938
3. do. do. ...	7,400	14,800	3,475,862	740
1. *Eucalyptus regnans* ... (Victorian Giant Gum)	5,100	12,662	3,110,400	784
2. do. do. ...	4,880	10,730	3,275,673	263
3. do. do. ...	3,730	846	3,240,625	207
1. *Eucalyptus resinifera* ... (Red Mahogany)	6,330	12,744	2,400,000	904
2. do. do. ...	7,240	15,242	2,204,220	905
3. do. do. ...	6,950	14,631	2,508,387	992
1. *Eucalyptus rostrata* ... (Murray Red Gum)	2,230	4,460	...	446
2. do. do. ...	5,000	10,000	...	555
3. do. do. ...	4,800	9,536	...	685
1. *Eucalyptus saligna* ... (Sydney Blue Gum)	5,330	11,605	2,200,754	761

TABULATED RESULTS—Continued.

Botanical Name. (Common Name.)	Breaking Load in Pounds.	Modulus of rupture in lbs. per sq. inch.	Modulus of elasticity in lbs. per square inch.	Rate of Load in lbs. per minute.
2. *Eucalyptus saligna* ...	6,000	13,235	2,916,000	750
3. do. do. ...	5,500	12,168	3,085,114	916
1. *Eucalyptus viminalis* ... (White Gum)	4,000	9,391	1,286,470	400
1. *Syncarpia laurifolia* ... (Turpentine)	5,810	12,269	1,656,818	645
2. do. do. ...	4,255	4,283	1,920,000	709
3. do. do. ...	5,750	1,2500	1,962,727	718
N.O. EBENACEÆ.				
1. *Diospyros pentamera* ... (Grey Plum or Black Myrtle)	4,225	9,859	...	...
2. do. do. ...	4,340	9,580	...	...
N.O. PROTEACEÆ.				
1. *Orites excelsa* ... ... Silky Oak)	5,550	10,744	1,561,234	504
2. do. do. ...	5,850	11,397	1,293,231	390
3. do. do. ...	4,750	9,238	...	327·6
1. *Banksia serrata* ... ... (Honeysuckle)	6,450	12,520	1,536,991	516
2. do. do. ...	7,500	14,569	1,730,769	500
3. do. do. ...	7,050	13,617	1,718,456	503
1. *Banksia integrifolia* ... (White Honeysuckle)	3,250	6,315	1,238,933	541
2. do. do. ...	3,900	7,593	1,068,622	325
N.O. CUPULIFERÆ.				
1. *Fagus Moorei* ... ... (Negro Head Beech)	4,550	9,868	2,005,515	350
1. *Fagus Cunninghamii* ... (Tasmanian Myrtle or Red Beech)	4,390	10,428	1,598,251	418
2. do. do.	5,120	10,716	1,435,569	569
N.O. CONIFERÆ.				
1. *Callitris tasmanica* ... (Pine)	5,690	11,380	1,515,789	711
2. do. do. ..	4,200	9,257	2,120,727	600
3. do. do. ...	4,000	8,000	1,440,400	550
1. *Callitris calcarata*... ... (Black or Cypress Pine)	1,200	2,416	1,028,571	109
2. do. do. ...	2,660	5,320	1,309,090	380
3. do. do. ...	2,540	5,341	1,458,000	423
1. *Callitris glauca* ... ... (Cypress or White Pine)	4,850	9,448	1,016,470	485
2. do. do. ...	4,290	8,529	1,133,160	451

TABULATED RESULTS—Continued.

Botanical Name. (Common Name.)	Breaking Load in Pounds.	Modulus of rupture in lbs. per sq. inch.	Modulus of elasticity in lbs. per square inch.	Rate of Load in lbs. per minute.
3. *Callitris glauca*	3,050	6,010	875,675	210
1. *Athrotaxis selaginoides* ... (King William Pine)	2,620	5,458	810,000	238
2. do. do. ...	2,580	5,160	822,857	215
3. do. do. ...	3,000	6,230	845,217	375
1. *Araucaria Cunninghamii* (Colonial Pine, Hoop Pine)	6,735	10,168	2,659,977	361
2. do. do. ...	6,600	12,963	2,777,142	414·5
1. do. do. ...	5,000	10,000	1,986,206	455
2. do. do. ...	5,350	10,700	2,133,333	446
3. do. do. ...	5,000	11,250	1,944,000	500
1. *Araucaria Bidwillii* ... (Bunya Bunya Pine)	3,210	6,420	1,028,571	458
2. do. do. ...	3,455	5,695	1,114,394	575
3. do. do. ...	2,890	4,480	873,707	578
1. *Dacrydium Franklinii* ... (Huon Pine)	4,5 15	9,121	2,445,283	410
2. do. do. ...	4,350	8,835	1,620,000	290
3. do. do. ...	3,000	6,000	1,270,588	500
1. *Phyllocladus rhomboidalis* (Celery Top Pine)	5,000	10,000	1,600,000	455
2. do. do. ...	5,470	11,013	1,728,000	547
3. do. do. ...	5,050	10,236	1,690,434	561
1. *Podocarpus elata* ... ... (Brown Pine)	4,254	8,508	1,053,658	425
2. do. do. ...	3,390	6,917	1,403,508	565
3. do. do. ...	4,450	9,475	1,366,875	635

FOREIGN TIMBERS.

1. Indian or Burmah Teak ...	7,750	14,145	1,510,153	553
3. do. do. ...	5,400	10,200	1,278,178	675
1. American Hickory ...	8,900	17,508	2,797,814	810
2. do. do. ...	9,345	19,536	2,880,000	667
1. American Ash	4,365	9,936	1,257,398	545
2. do.	3,823	8,238	1,041,111	637
3. do.	5,220	11,185	1,570,810	...
1. Oregon	5,740	11,557	2,250,000	441
2. do.	5,660	11,472	1,991,803	514
3. do.	5,520	11,076	1,854,077	613
4. do.	5,000	12,149	...	...
5. do.	5,000	12,637	...	...

TABULATED RESULTS—Continued.

Botanical Name. (Common Name.)	Breaking Load in Pounds.	Modulus of rupture in lbs. per sq. inch.	Modulus of elasticity in lbs. per square inch.	Rate of Load in lbs. per minute.
1. Clear Pine...	3,346	6,570	...	...
2. do.	4,120	8,158	...	...
3. do.	3,725	7,018	...	...
1. American Redwood ...	5,100	10,200	1,565,217	510
2. do.	3,500	7,010	1,524,705	350
3. do.	5,130	10,613	1,690,217	570
1. Pitch Pine...	8,000	15,686	2,717,825	296
2. do.	7,600	15,000	2,061,384	760
3. do.	7,000	14,000	2,273,684	636
1. Japanese Pine	4,000	9,424	1,325,454	800
2. do.	3,775	9,208	1,035,266	377
3. do.	3,300	9,166	1,500,000	412
1. Red Baltic Pine	5,100	11,149	2,087,584	463
2. do.	5,600	12,573	2,168,029	560
3. do.	5,200	11,675	2,943,596	520
1. White Baltic Pine ...	2,510	6,435	1,714,285	358
2. do.	2,555	6,328	1,749,600	425
3. do.	3,745	9,276	1,682,307	416
1. Pacific Pine	3,000	6,000	1,440,000	500
2. do.	3,200	6,400	1,183,561	640
3. do.	3,500	7,000	1,270,588	700

V. Vernacular Names of Timbers Tested.

American Ash
American Hickory
American Redwood
Ash (American)
Baltic Pine (Red)
Baltic Pine (White)
Beech (Red)
Black or Cypress Pine
Blackbutt
Black Myrtle (Grey Plum)
Blackwood
Blue Gum (Sydney)
Brown Pine
Burmah Teak
Messmate
Mountain Ash
Murray River Red Gum
Myrtle (Tasmanian)
New England Peppermint
Negor Head Beech
Oregon
Pacific Pine
Peppermint (New England)
Pine (Clear)
Pitch Pine
Queensland Maple
Red Wood (American)
Red Beech

Celery Top Pine
Clear Pine
Coachwood
Colonial Pine (Hoop Pine)
Crow's-foot Elm
Giant Gum
Grey Ironbark
Grey Plum (Black Myrtle)
Hickory (American)
Honeysuckle
Hoop Pine (Colonial Pine)
Huon Pine
Japanese Pine
Jarrah
King William Pine
Mahogany (Red)
Mararie
Red Mahogany
Red Stringybark
Silky Oak
Silvertop Stringybark
Spotted Gum
Stringybark
Stringybark
Tallow-wood
Tasmanian Myrtle
Teak (Burmah) Indian
Teak (N.S.W. and Queensland)
Turpentine
White or Cypress Pine
White Gum
White Honeysuckle
White Ironbark
Woollybutt

SOME PHYSICO-CHEMICAL MEASUREMENTS ON MILK.

By H. B. TAYLOR, B.Sc.,

Science Research Scholar, University of Sydney.

(Communicated by Professor Fawsitt.)

[*Read before the Royal Society of N. S. Wales, November 5, 1913.*]

Milk, being the secretion of a living animal, is liable to variations in its composition owing to the influence of internal and external conditions. It is essentially an aqueous solution of milk sugar, proteins and salts, holding in suspension fat in the form of finely divided particles. Winter Blyth gives the average composition as follows:—

Fat ...	3·90	per cent. by weight.
Caseinogen	3·00	,, ,,
Albumen ...	0·40	,, ,,
Milk Sugar	4·75	,, ,,
Ash ...	0·75	,, ,,
Water ...	87·20	,, ,,

The quality of a milk can be fairly well gauged by the chemical determinations of its constituents, but it was thought desirable to investigate some of the physical properties of milk in the hope that the results might help in the matter of forming an opinion as to its quality. This paper contains an account of experiments on the viscosity, conductivity and reaction to indicators of milk.

Viscosity.[1]

The measurement of the viscosity was carried out with a capillary viscosimeter, the type used being Ostwald's modification of Poiseuille's apparatus.

[1] The numbers given as the viscosities are the values of $t_2\rho_2/t_1\rho_1$, where t_2 and t_1 are the times of flow of equal volumes of milk and water respectively, and ρ_2 and ρ_1 the densities.

In Table I are given the results of viscosity determinations on a number of milks at 20° C. These determinations were carried out on the milk in every case within four hours from the time of milking, so that no appreciable amount of decomposition could have taken place.

Table I.

Viscosity 20° C.	Total Solids.	Fat.	Solids not Fat.
2·024	15·17	5·75	9·42
2·006	14·65	5·40	9·25
2·029	15·05	5·75	9·30
1·951	14·46	5·00	9·46
1·997	14·60	5·40	9·20
1·961	13·88	4·70	9·18
1·982	14·20	5·10	9·10
1·997	14·61	5·40	9·21
2·059	14·90	5·30	9·60
1·984	14·60	5·20	9·40
1·953	14·29	5·15	9·14
2·042	14·54	5·00	9·54

It would appear likely, from a consideration of the above results, that a relation exists between the viscosity and the solids of a milk. Since it is seen that the viscosity is not directly proportional to the total solids, this relation if it exists will probably be a function of the fat and the solids not fat. To arrive at this relation, a sample of milk was taken and the decrease in viscosity noted due to the removal of part of the fat. The analysis of the sample experimented upon was as follows:—

Total solids	15·05	per cent.
Fat ...	5·75	,,
Solids not fat	9·30	,,

The time of flow of the milk in the viscosity apparatus was 190·2 seconds as compared with 96·6 for water alone. After removal of 2·05 per cent. of fat, the time of flow was

177·5 and after removal of 4·4 per cent. of fat the time of flow was 162·6. The average decrease in the time of flow was 6·22 seconds for every one per cent. of fat removed. This would leave a time of flow of 154·43 seconds for a solution of the constituents other than fat.

In the analysis given above the percentage of solids not fat is 9·30. The time of flow of the volume containing one per cent. solid not fat is therefore 16·61. Putting these figures in the shape of a formula we have,

$$\text{p.c. solids not fat} = \frac{\text{Time of flow} - \text{p.c. fat} \times 6{\cdot}22}{16{\cdot}61}$$

$$\text{or p.c. solids not fat} = \frac{\text{Viscosity} - \text{p.c. fat} \times {\cdot}0665}{{\cdot}177}$$

On applying this formula to the sample given above we see from Table II that the agreement between calculated and observed results is satisfactory, when consideration is taken of the fact that the determination of total solids by the usual method of drying in a steam oven is not altogether satisfactory. In the determinations of the total solids given below the drying was continued for three hours.

Table II.

Viscosity.	Total Solids (weighed).	Total Solids (calculated).
2·024	15·17	15·03
2·006	14·65	14·70
2·029	15·05	15·05
1·951	14·46	14·14
1·984	14·60	14·46
1·953	14·29	14·25
1·997	14·60	14·65
1·961	13·88	14·01
1·982	14·20	14·38
1·997	14·61	14·46
2·059	14·90	14·94
2·042	14·54	14·65

The close agreement in the majority of cases between observed and calculated results, shows, that a relation does exist between the viscosity and the solids of a milk, and that this relation is a function of the fat and of the solids not fat, rather than of the total solids.

Change of Viscosity with Increase of Temperature.

On heating, the viscosity of a milk rapidly decreases, such decrease being approximately 4·5 per cent. between 20° and 30° C. In order to obtain a relationship between the viscosity and the temperature, the viscosities given in Table III were obtained for a sample of milk.

Table III.

Temperature ° C.	Viscosity.
20	2·100
25	2·034
30	1·987

By substituting these values for n_0 and n_t in Poiseuille's formula,

$$n_t = \frac{n_0}{1 + \alpha t + \beta t^2}$$

where n_0 is the viscosity at 0° C.and n_t the viscosity at $t°$, the values of the constants α and β were found to be

$$\alpha = \cdot 00723 \qquad \beta = -\cdot 000156$$

In Table IV are given the values, for a number of milks at a temperature of 40° C., of the observed viscosities and also of the viscosities calculated by means of the above formula.

Table IV.

Viscosity 20° C.	Viscosity 40° C. (observed).	Viscosity 40° C. (calculated).
2·006	1·853	1·853
2·029	1·870	1·875
1·951	1·800	1·802
1·984	1·834	1·833
1·992	1·845	1·840

Viscosity 20° C.	Viscosity 40° C. (observed).	Viscosity 40° C. (calculated).
2·032	1·878	1·878
1·953	1·812	1·805
1·997	1·844	1·845
1·966	1·823	1·817
1·961	1·812	1·812

The figures given above represent the viscosities of the milk at 20° C. and 40° C. relative to water at the same temperature. It is well known that when milk is heated to a temperature of about 70° C. a change takes place which is said to render the milk less digestible. If this change takes place in those constituents which have a large influence on the viscosity, it should be possible to detect a change in the viscosity. With this in view experiments were carried out in such a manner that samples of milk were heated to the desired temperature and then cooled to 20° C. again, when the time of flow was measured. When, in successive determinations with increasing temperatures, the temperature to which the milk was heated reached 70° C. the viscosity began to increase, showing that a precipitation or coagulation was taking place. By following the above procedure the results given in Table V were obtained.

Table V.

I.		II.		III.	
Temp. milk heated to	Time of flow at 20° C.	Temp. milk heated to	Time of flow at 20° C.	Temp. milk heated to	Time of flow at 20° C.
25	162·0	20	201·0	20	186·0
45	158·5	40	199·2	60	181·8
50	160·4	60	195·0	70	183·5
65	159·4	80	203·6	75	192·0

The figures show that the change, which is probably a coagulation of the albumen, takes place close to 70° C.

It was found that the electrical conductivity of a sample of milk did not change by heating to a temperature of 70° C.

for five minutes and then cooling down. This points to the fact that the change takes place in the non-conducting constituents of the milk.

It will also be noticed that before the change takes place, which increases the time of flow, another change manifests itself which has the effect of decreasing the time of flow, so it would seem, that on heating milk two changes take place, (1) a liquefaction, (2) a coagulation.

The Electrical Conductivity of Milk.

Since the quality and the quantity of cow's milk is influenced by so many factors, such as the breed of cow, feeding, weather conditions, etc., it is to be expected that considerable variations would occur in the conductivities of different milks. The conducting constituents of a milk are its soluble salts. The proportion in which the mineral salts exist in milk is given by Soldner as follows:—

Sodium chloride	10·62	per cent.
Potassium chloride	9·16	,,
Mono potassium phosphate ...	12·77	,,
Di-potassium phosphate ...	9·22	,,
Potassium citrate	5·47	,,
Di-magnesium phosphate ...	3·71	,,
Magnesium citrate	4·05	,,
Di-calcium phosphate... ...	7·42	,,
Tri-calcium phosphate ...	8·90	,,
Calcium citrate	23·55	,,
Lime combined with proteins	5·13	,,

It will be seen from the above analysis that the chlorides and citrates comprise 52·85 per cent. of these salts, the remainder being phosphates of which a great part is held in suspension and thus can have little effect on the conductivity. Potassium chloride has a specific conductivity of $4{\cdot}3 \times 10^{-3}$ reciprocal ohms at 26° C., for an $n/32$ solution, the value for the corresponding citrate is $2{\cdot}2 \times 10^{-3}$. A

small interchange of the percentage values between potassium chloride and citrate would therefore make an appreciable change in the conductivity of the milk. The conductivities given below in Table VI represent the specific conductivities of a series of milks at 26° C., and the corresponding ash as obtained by burning off the organic matter at a temperature below read heat.

Table VI.

Specific Conductivity $\times 10^2$.	Ash per cent.
·4282	·71
·4651	·72
·4467	·72
·4642	·73
·4572	·76
·4623	·79

From the above figures it is seen that the conductivity is not proportional to the ash. The difference is probably due not only to the variation in composition of the ash but also to the presence of varying amounts of other constituents.

Increase in conductivity due to the removal of fat.

When fat is separated from milk the conductivity increases. This increase is probably due to two things—

(1) the increase due to the concentration of the salts,

(2) that due to the removal of obstacles from the path of the ions.

In regard to the first, the analyses of a sample of milk, before and after 4·5 per cent. of fat was removed are given below; it will be seen that the figure for the solids not fat in the separated portion is 4·5 per cent. higher than in the original sample.

	Before separation.	After separation.
Total solids	14·29	10·10
Fat	5·15	·60
Solids not fat	9·14	9·50

The mean increase in conductivity from five experiments for the removal of 5 per cent. of fat was 11·4 per cent. of the conductivity. It was also found that the decrease in conductivity for the addition of 5 per cent. of water corresponded to a decrease of 3·6 per cent. This shows that the increase in conductivity due to the removal of 5 per cent. of fat is greater than the increase which would be due to a removal of 5 per cent. of water, which can be explained by attributing to the fat globules an obstructing influence on the ions in their passage through the solution.

The Hydrogen Ion concentration of milk.

The presence of H ion in milk is due to the hydrolysis of certain of the salts present in it and the dissociation of the lactic acid produced in its decomposition. This decomposition is brought about, in the case of healthy cows, by the action of those bacteria which have gained access to the milk either after or during the process of milking.

Among the bacteria which gain access are those having the power to form lactic acid from the milk sugar; these are of two kinds:—

(1) *B. lactis ærogenes* and its allies,

(2) *B. acidi lactici* or *Streptococcus lacticus.*

The former forms in addition to lactic acid, volatile acids, ethyl alcohol etc., while the latter forms almost exclusively pure lactic acid. It has been shown by Heinemann[1] that milk allowed to sour naturally at about 20° C. contains chiefly dextro-lactic acid, that soured at 37° C. chiefly racemic acid with lævo in excess if allowed to stand for several days. The lactic acid formed by these bacilli is not produced directly from the lactose but from the simpler sugars glucose and galactose, formed from the lactose by the action of certain enzymes. The decomposition may also be carried to butyric acid with the evolution of hydrogen and carbon dioxide.

[1] Journal of Biological Chemistry, Vol. II, No. 6, p. 603, 1907.

Fresh milk when titrated with ·1 normal NaOH has an apparent acidity of ·2 per cent., calculated as lactic acid; this is due to the presence in the milk of a salt, primary sodium phosphate, which in the presence of NaOH is converted into secondary sodium phosphate as follows,

$$NaH_2PO_4 + NaOH = Na_2HPO_4 + H_2O.$$

The amount of alkali that it is necessary to add to 5 cc. of milk to give an alkaline reaction to phenolphthalein is 1·2 cc. Also when milk is titrated with an acid a similar change takes place,

$$Na_2HPO_4 + HCl = NaH_2PO_4 + NaCl,$$

with the production of a salt of greater H ion concentration. The amount of ·1 normal hydrchloric acid necessary to give to 5 cc. of fresh milk an acid reaction to methyl orange is 5 cc.

The reaction of fresh milk towards litmus is what is known as an amphoteric reaction, *i.e.*, it turns red litmus blue and blue litmus red. Since neutral litmus is rendered red by the addition of an acid, *i.e.*, increasing its H ion concentration and blue by decreasing its H ion content, red and blue litmus must have different H ion concentrations. If a piece of red litmus paper is moistened with an H ion solution of concentration between red and blue litmus it will change colour towards the blue; similarly blue litmus dipped in the same solution will tend towards the same colour. The amphoteric reaction of milk to litmus probably depends therefore simply on the fact that its H ion concentration lies between those of red and blue litmus. It was thought that some new light might be thrown on the quality of a milk by investigating the H ion concentration of milk rather than the total acidity.

Two methods of determining the H ion concentration of milk suggest themselves:—the E.M.F. method, and a method depending on the use of indicators. Both methods

were used, and, as carried out, gave similar results, but the E.M.F. method is more sensitive and more accurate. The first experiments on this matter were conducted by the E.M.F. method and then the indicators were used after finding out that this latter method was sufficiently accurate for the purpose.

E.M.F. Method.

This method was carried out with the usual apparatus described in Ostwald—Luther's "Hand und Hilfsbuch." A platinum electrode saturated with hydrogen and inserted in milk was connected with a deci-normal calomel electrode and the E.M.F. of the combination determined. From this the concentration of H ion was calculated.

Sorensen[1] gives the formula

$$p_h = \frac{\pi - 0{\cdot}3377}{0{\cdot}0577} \text{ at } 18^\circ \text{ C.}$$

for calculating the concentration of hydrogen ion from the E.M.F. (π). This formula was used by the author, after being assured of its accuracy by experimental confirmation in a considerable number of cases.

For the purpose of these determinations a number of carefully prepared standard solutions were made according to the manner described by Sorensen. These standard solutions were made up from the following:—

(1) ·1 molecular hydrochloric acid.
(2) ·1 molecular di-sodium-hydrogen citrate.
(3) ·1 molecular sodium hydrate.
(4) 1/15 molecular potassium-di-hydrogen phosphate.
(5) 1/15 molecular di-sodium-hydrogen phosphate.

The method of expressing the concentration of hydrogen ion in the solutions is also the method used by Sorensen. The concentration is expressed in this way as a power of ten and the index alone used to represent the concentration.

---

[1] Biochem. Zeit., XXI, p. 166, 1909.

In the following table (Table VII) are some of the determinations made on mixtures of the standard solutions, giving the E.M.F. and the value for the H ion calculated from this figure. The numbers in the last column are the negative indices to which ten is raised, *i.e.* 4·43, means $10^{-4\cdot43}$

Table VII.

Solution.		E.M.F.	H. ion.
15 cc. Hcl.	+ 35 cc. citrate ...	·5932	4·43
10 ,,	+ 40 ,, ...	·6049	4·63
5 ,,	+ 45 ,, ...	·6159	4·82
0 ,,	+ 50 ,, ...	·6223	4·93
5 cc. NaOH	+ 45 ,, ...	·6336	5·13
10 ,,	+ 40 ,, ...	·6453	5·33
15 ,,	+ 35 ,, ...	·6600	5·58
20 ,,	+ 30 ,, ...	·6820	5·96
10 cc. sec. phos.	+ 40 cc. prim phos.	·6942	6·18
15 ,,	+ 35 ,,	·7082	6·42
25 ,,	+ 25 ,,	·7285	6·77
30 ,,	+ 20 ,,	·7405	6·98

In regard to the determinations of H ion concentrations in milk, it might be doubted whether the fat and other constituents interfered with the method. To ensure that the correct result is obtained when E.M.F. determinations are made on the milk, the H ion concentrations at various dilutions were obtained, and the H ion values plotted against the logarithms of the concentrations. This was done both with the fresh milk, and with milk where the H ion had reached its maximum value. As will be seen from figures 1 and 2, both the graphs are straight lines, passing through the values obtained for the undiluted milk, showing that the correct result is obtained by determinations made on the pure milk, that the H ion is proportional to the logarithm of the concentration and that fat in the milk has no effect on H ion determinations.

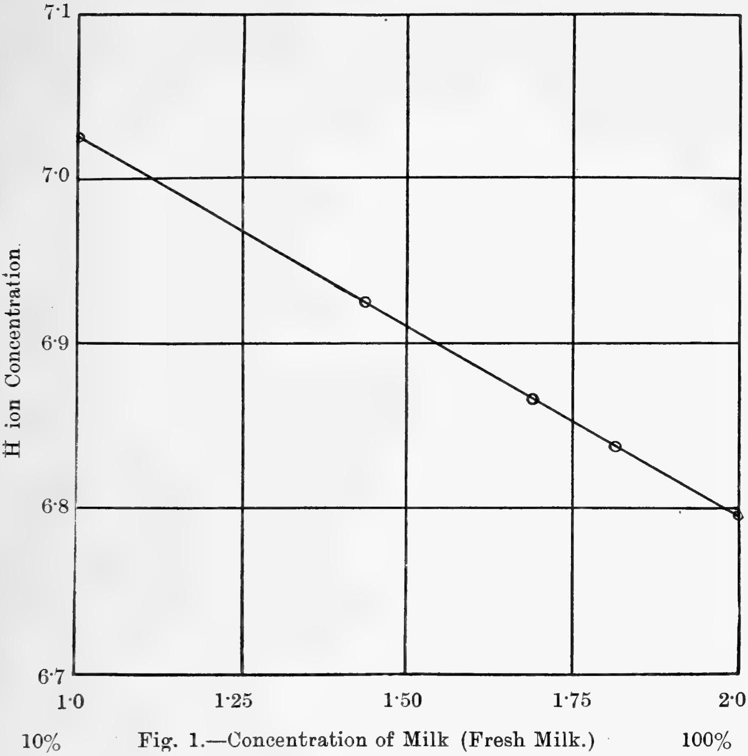


Fig. 1.—Concentration of Milk (Fresh Milk.)

Indicator Method.

Having found from E.M.F. measurements between what values the H ion in the milk varies, it was decided to use 1 per cent. solution of methyl red and rosolic acid in alcohol as indicators, to determine from colour changes the H ion concentration. These two indicators have been found satisfactory.

It was soon found to be impossible to observe the change of colour which takes place on adding a few drops of indicator to milk owing to its opacity. It has however been found practicable to add a few drops of milk to a small quantity of indicator in water, and compare the colour

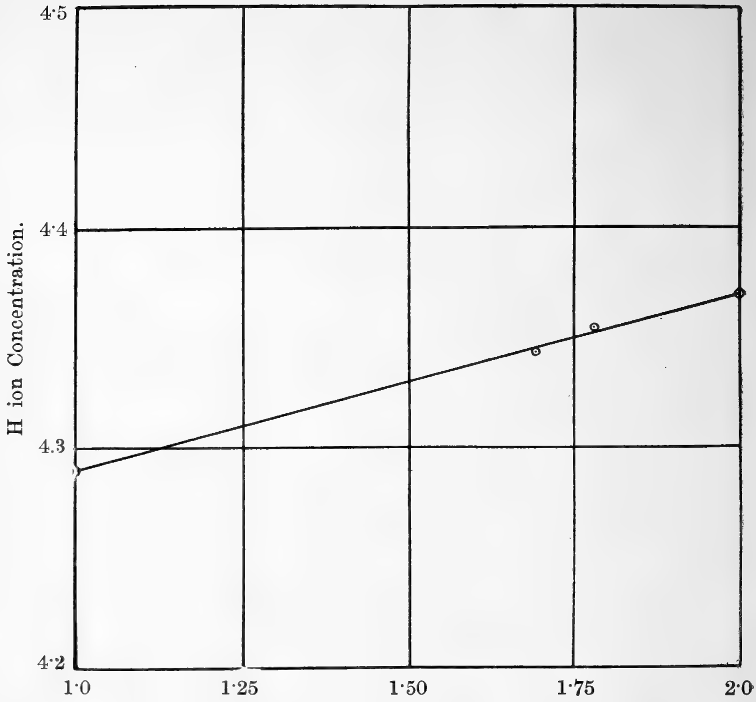


Fig. 2.—Concentration of Milk (Milk 36 hours old).

observed with that obtained by adding a few drops of one of the standards (such as are given in Table VII) to the same quantity of indicator and water.

It appears at first not unlikely that milk and these phosphate or citrate solutions might have the H ion changed by dilution to very different extents; however, this does not appear to be the case, as the result for the H ion concentration obtained from the use of indicators with diluted milk and diluted solutions are almost identical with results obtained by E.M.F. measurements. In the following table are given a few figures showing the agreement between values for the H ion concentration of milk obtained by both methods,

Table VIII.

E.M.F.	H ion.	H ion (indicator).
·7334	6·86	6·85
·6645	5·66	5·70
·6225	4·93	5·00
·6042	4·62	4·70
·5870	4·42	4·35

In determining the H ion concentration of the milk at any time, a number of ordinary test tubes of the same bore and thickness were used. A solution of the indicator (1 drop to 20 cc. of water) was made, and 10 cc. of this solution delivered to each tube. Having prepared a number of tubes in this way, two drops of a solution of known H ion concentration were added to the first tube, then the same amount of a different concentration to the second tube, and so on, until a sufficient number of tubes were obtained containing different intensities of colour. It was found that two drops of any of the above solutions were sufficient to give an intensity of colour closely approximating to the maximum colour. The change produced by a further addition of H ion of the concentration previously added being negligible when compared with the change in intensity due to a solution ·1 higher in its H ion concentration.

A similar experiment with milk instead of one of the standard solutions enabled a comparison to be made between milk and these solutions, and so gave the desired figure for the concentration of H ion. In this case the colour produced was destroyed after about 12 hours. In obtaining a sample of milk the cow was milked without special precautions, the milk well mixed and a portion received into a sterilized bottle the neck of which was closed with cotton wool, so that the subsequent decomposition was due to the micro-organisms which gained access during the milking process.

It will be seen from the following table that temperature plays a large part in the rate at which the H ion concentration of the milk increases,

Table IX.

Hours old.	H ion at 30° C.	H ion at 25° C.
7·0	6·80	6·80
11·0	6·60	6·65
14·0	6·40	6·60
17·5	5·30	5·50
19·0	5·10	5·45
21·0	4·80	5·35
23·0	4·65	4·80
24·5	4·65	4·70
25·5	4·65	4·70
30·5	4·65	4·65
102·5	4·65	4·65

At a temperature of 30° C. the maximum value for the H ion was reached in 23 hours, at the temperature of 25°C. it took 7·5 hour longer to gain the same figure. The period lapsing between the time of milking the cow and the time when acid began to be produced was on an average, at a temperature of 30° C., about seven hours, and the formation of acid continues until enough acid is formed to inhibit the growth of the bacteria present, as shown by the constant figure for the H ion at the bottom of the above table.

Figure three gives a graphical representation of the increase of the H ion along with the time in one sample of milk.

In the seventeen samples which were examined, the average value for the H ion concentration of the fresh sample was 6·83, one sample gave a value of 7·1 the remainder varying from 6·7 to 6·9, these figures show that in the majority of cases milk as received from the cow is very slightly acid, this acidity being due to a slight excess

of acid salts over alkaline ones. At a temperature of 30°C. the H ion attained its maximum value after about twenty-four hours, and in the samples examined this value varied from 4·3 to 4·65.

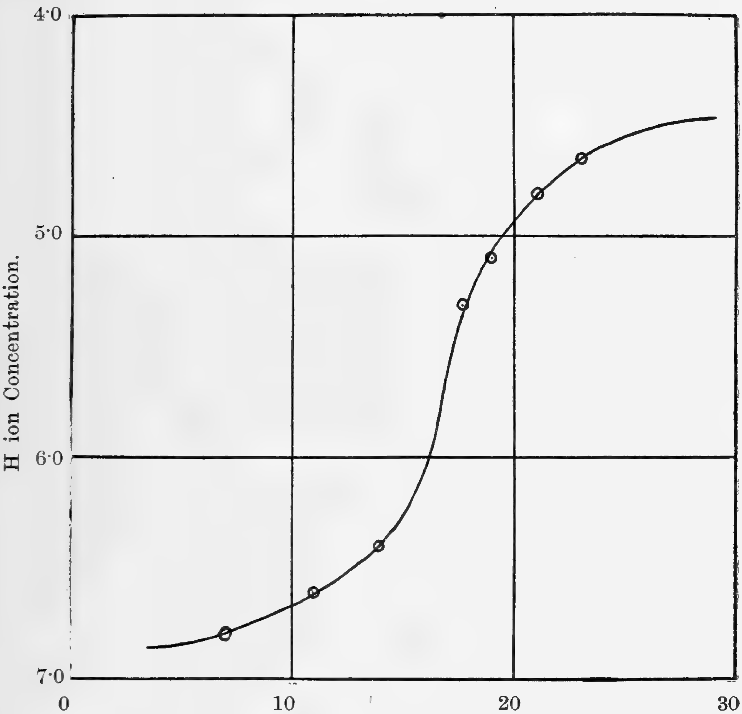


Fig. 3.—Time hours.

The curdling of the milk, which is brought about by the precipitation of the caseinogen by the acid formed, took place in the sample under observation at a temperature of 30° C. when the acidity calculated as lactic acid reached a value of ·73 per cent., which corresponded to a H ion value of 4·9; this value was arrived at when the milk was 20 hours old.

Loss in total solids through decomposition.

The decomposition of milk due to the agency of bacteria is accompanied by a decrease in the percentage of total solids. The total solids were determined by evaporating to dryness 5 grams of milk over a steam bath, and then drying for three hours in a steam oven. The first evidence of a decrease was obtained at the same time as a change in the H ion concentration and acidity was noticed. For milk kept at a temperature of 30° C. the average loss in total solids was ·44, corresponding to a percentage loss of 3·84 for the original total solids present.

In the table given below, the figures in the first column represent the percentage of total solids at time 0 hours, those in the second column the value after 24 hours. All the samples were kept in a thermostat at 30° C., the neck of each bottle being closed with cotton wool.

Table X.

% T.S. at t_0	% T.S. at t_{24}	Decrease in T.S.	% Decrease.
13·09	12·40	·69	5·27
14·69	14·51	·18	1·23
13·01	12·60	·41	3·20
14·16	13·37	·79	5·60
13·60	13·20	·40	2·93
14·80	14·50	·30	2·03
14·16	13·70	·46	3·25
12·86	12·33	·53	4·17
13·02	12·36	·66	5·08
12·35	11·90	·45	3·65
16·82	15·03	·79	4·70
12·47	11·84	·63	5·05

It may be of general interest to see what effect the weather conditions have on the rate at which milk decomposes (*i.e.*) how the weather conditions affect the number of bacteria gaining access to the milk. To show this the

following table was drawn up, showing the weather conditions on the days the samples were taken, and the subsequent percentage decrease in the total solids in twenty-four hours.

Table XI.

February. 1913.	Weather conditions at 12·30.					% decrease of T.S.
2	slight showers,	S.E.	wind,	8	miles per hour	—
3	cloudy,	S.E.	,,	8	,,	5·27
4	fine,	N.E.	,,	20	,,	1·23
5	fine, squally	S.E.	,,	15	,,	3·20
9	slight showers,	S.E.	,,	8	,,	—
10	cloudy and squally	S.	,,	25	,,	5·60
11	showery all day,	S.	,,	15	,,	2·93
12	cloudy,	S.	,,	17	,,	2·03
13	fine, gusty,	N.E.	,,	16	,,	3·25
16	fine,	E.	,,	10	,,	—
17	fine,	N.E.	,,	11	,,	4·15
18	fine, hot 100·5°F.	W.	,,	13	,,	—
19	fine,	E.	,,	15	,,	5·08
20	cloudy,	S.E.	,,	18	,,	—
21	overcast,	E.	,,	7	,,	3·65
23	fine,		,,		,,	—
24	fine, sultry,	E.	,,	15	,,	4·70
26	fine,	N.E.	,,	18	,,	—
27	fine, squally	N.E.	,,	19	,,	5·05

All the samples were taken at 12·30 p.m., the shed in which the cows were milked ran north and south, the only door being at the southern end. In all cases where a large decrease was noticed, the weather conditions were such that a large amount of dust could reasonably be expected to be present in the air, such conditions being a high wind or when no rain had fallen for some time, etc.; on the other hand when it had been raining the decomposition was, in in all cases, small. The above table should make clear the

necessity for all vessels containing milk to be kept covered, as pathogenic bacteria carried around on the dust particles are just as likely to fall into milk as the harmless bacilli producing lactic acid.

Summary.

1. The viscosity of milk is related to the percentage of fat and to the solids other than fat in the milk. A formula was derived which permitted the calculation of "solids not fat" from a determination of the viscosity, and the fat of milk. The viscosity of milk decreases with rise of temperature in a regular way from 20 to 40° C. which can be expressed by means of the usual equation

$$n_t = \frac{n_0}{1 + \alpha t + \beta t^2}.$$

Apart from the general decrease in viscosity, milk which has been heated from 20° C. to any temperature up to 60°C. is found to have decreased in viscosity, when brought back to the original temperature 20° C. Milk heated to 70° C. and recooled is found to have increased in viscosity.

2. The electrical conductivity of milk is due to the solids other than fat, the action of the fat globules being to lower the conductivity.

3. The H ion concentration of normal fresh milk is $10^{-6 \cdot 8}$ and after the milk has soured the concentration is $10^{-4 \cdot 65}$; these values did not vary to any great extent from one cow to another in a considerable number of samples.

4. It is shown that the decomposition of milk which has stood 24 hours is most rapid on the days when the operation of milking has been conducted with a strong dusty wind blowing.

These investigations were carried out in the Chemical Laboratory of the University of Sydney, and I wish to express my thanks to Professor Fawsitt for his advice throughout the work.

ON THE AUSTRALIAN MELALEUCAS AND THEIR ESSENTIAL OILS, Part V.

By R. T. BAKER, F.L.S., and H. G. SMITH, F.C.S.

[With Plate VIII.]

[*Read before the Royal Society of N. S. Wales, November 5, 1913.*]

SUMMARY:—

1. Introduction.
2. Historical.
3. Systematic Botany.
4. Remarks on synonymised species.
5. Range of species.
6. Chemistry of Essential Oils.
    - *a.* "Cajuput" from *M. minor*, Linn.
    - *b.* *M. Maideni*, R.T.B.
    - *c.* *M. Smithii*, R.T.B.

I. Introduction.

Perhaps a more correct title to this paper would be "*Melaleuca leucadendron*, Linn., its alleged synonyms and their Essential Oils," for that is the ground it covers, but it was thought better not to break the continuity of this series of Melaleuca research in spite of a strong inducement to do so.

The literature published on this particular species shows that much confusion has existed in the minds of systematists, as to what species showing affinity to Linnæus' should be synonymised with, or differentiated from it, and this is specially the case in such botanical works as Bentham's Flora Australiensis, and Hooker's Flora of British India.

To elucidate this difficulty gave us much trouble and absorbed much time. However, we think that having

reached the end of our investigations, nothing further remains than to publish the results which are given in this paper.

II. Historical.

The first species described under the generic name Melaleuca was *M. leucadendron* by Linnæus in Mantiss., 105, 1767, from Indian specimens.

There had been imported into Europe from the East, about the beginning of the seventeenth century an oil under the name of "Cajoepoeli" (according to Linnæus' spelling, *infra*) but under a later spelling "Cajuput." At that time and long after its introduction, the botanical origin was ascribed to Linnæus' species (*supra*), as the specimens forwarded to Linnæus were reputed to be taken from trees from which the oil was obtained, and he evidently described it under that impression, as shown by his original specimen now in the possession of the London Linnean Society and labelled by him "Cajoepoeli" and afterwards by Smith as *Melaleuca leucadendron*, *vera*, a photograph of which is reproduced at the end of this paper, Plate VIII.

This reputed origin of the oil, however, was shown later by Roxburgh to be an error, and that the true source of "Cajuput" was a Melaleuca which he named *M. cajuputi*, but this was found later to be identical with *M. minor*, described earlier in 1813 by Smith in Rees' Cyclop., Vol. XXIII, and so quite a distinct tree from that to which Linnæus had given the above name. However, many European systematists in the last century regarded the two as one, but the early Indian botanists being very emphatic over the matter, always kept them distinct, and our investigations support the latter botanists.

Since the original description by Linnæus was published, several species have been described which had the general facies of his tree but differed in some important characters.

These species, recent botanists working on indoor or herbarium material have synonymised generally under *M. leucadendron*, the list standing as follow:—

M. minor, Sm.	*M. lancifolia*, Turcz.
M. Cunninghami, Schau.	*M. Cumingiana*, Turcz.
M. saligna, Blume.	*M. lanceolata*, R. Br. (Herb.)
M. viridiflora, Soland.	*M. Sieberi*, Schau.

The last two are the *M. leucadendron*, var. *parvifolia* Bentham, Flora Australiensis, iii, p. 143.

Having seen recently a statement to the effect that Linnæus' original specimen of *M. leucadendron* was in the Herbarium of the London Linnean Society, in order to settle the question definitely, we wrote to Dr. Daydon Jackson, Secretary to the Society, asking him if he would kindly compare a series which we were sending him, obtained from Sydney and round the East and North Coasts of Australia, of the Melaleucas in dispute, and mark the one or any of them which should prove to be identical with the original.

In his reply he states:—

"I am not able to match any of the specimens you sent, which I now return, but a specimen from Java seems to be the nearest, and I have indicated that with a strip of paper. I also send you a photograph about half-scale of the first sheet in the Linnean Herbarium which bears the words in the hand-writing of Linnæus "Cajoepoeli" = Kajoe-poetih of the natives in a Dutch rendering and = *Melaleuca leucadendron.* Linnæus also refers to Rumph. Amb., and I put in a tracing of part of tab. 16 of Vol. II, showing the falcate foliage.

"The material before me belonging to the Linnean Herbarium is as follows:—

'1. The first sheet (see photograph); Smith has added at the foot of the sheet, not shown in photograph, *M. leucadendron vera.* J.E.S.'"

This photograph throws some doubt on *M. leucadendron*, Linn., as being an Australian species, but comparing it with specimens in the National Herbaria of Sydney and Melbourne, from Arnheim Land, Napier, Broome Bay, Burdekin, Escape Cliff, these appear somewhat to match it, but until material is obtained from India, the home of the original, and compared botanically and chemically with Australian material, in our opinion the name *M. leucadendron*, Linn. should be held in abeyance as applying to an Australian species.

Morphologically therefore, it is not any of those investigated by us nor does it agree chemically.

That the Melaleuca on the N.W. Coast of the Continent differs from that of other Eastern Coast species is evident from the remarks of Mr. W. S. Campbell, which appeared in the "Sydney Morning Herald of October 6th, 1913, who when describing a trip to those parts of the Continent, states:—

"Here and throughout the country, in the many favourable moist places, the tea tree, *Melaleuca leucadendron*, abounds. Along the banks of rivers, creeks, and many lagoons and swampy localities, it attains a great height and diameter. Overhanging the water amongst other vegetation, with its silvery green, pendulous leaves, it adds greatly to the beauty of many beautiful places. *This tree seems to differ to some extent from that bearing the same name in New South Wales*, and which is very common about the coast, the leaves being more willowy-like."

Concerning these Tea-trees, Mr. W. H. Tibbits, L.S., Woollahra, writes:—

"These trees also grow in the Cape York Peninsula and out from Cooktown." This tree is very probably *M. saligna*, Schau.

III. Systematic Botany.

Bentham evidently experienced great difficulty in classifying his material under this species (*M. leucadendron*)

when preparing his Flora Australiensis, for there he states, Vol. III, p. 142 :—

"This species, widely spread and abundant in the Indian Archipelago and Malayan Peninsula, varies exceedingly in the size, shape and texture of the leaves, in the young shoots, very silky-villous or woolly, or the whole quite glabrous; in the short and dense or long and interrupted spikes; in the size of the flowers; in the greenish-yellow, whitish, pink, or purple stamens, etc., and at first sight it is difficult to believe that they all can be forms of one species, but on examination none of these varieties are sufficiently constant or so combined as to allow of distinct races."

J. F. Duthie who wrote the Myrtaceæ portion of Hooker's Flora of British India, reproduces these remarks, Vol. II, p. 463, and divides the species into two varieties, viz:—var. *leucadendron*, var. *minor*.

The only difference he makes in these two forms is that the former has glabrous spikes, whilst in the latter they are villous.

De Candolle in his Prodromus, Part III. p. 212, lists *M. leucadendron*, Linn. and *M. minor*, Smith, giving specific differences practically similar to the varietal ones of Duthie; more recently Bailey makes three varieties, viz:—var. *lancifolia*, var. *saligna*, var. *Cunninghami*.

Not only are we inclined to regard *M. leucadendron*, Linn. as extra-Australian, but also *M. minor*, Smith,—the source of Cajuput oil; but in order to throw further light on the subject, specimens were obtained from Dr. M. Treub, Director of the Department of Agriculture, Buitenzorg, Java, who very kindly sent us full material—flowering and fruiting specimens and a large supply of oil obtained from that species, or *M. cajuputi* as he states.

This botanical material matches very well the coloured figure of *M. minor*, Sm., in Bentley and Trimen, Medicinal Plants, Vol. II, p. 108. The leaves are of rather a thin

texture, almost membraneous, rarely 4″ long, mostly under 3″ and about $\frac{1}{2}$″ wide, ovate, straight, now and again falcate. Venation fine, varying in number from 3 to 5 prominent ones, the flowering rachis having a white silky pubescence, flowers distant.

This, evidently, then is the true *M. minor* of Smith and at any rate is the species from which cajuput oil is obtained, for the analysis of this specimen of oil agrees with the published analyses of cajuput oil, and differs from those of all Australian Tea Trees going under the name of *M. leucadendron*. It must also be stated that Treub's specimens differ botanically from any Australian material seen by us.

IV. Remarks on the Species Synonymised under *M. leucadendron*, Linn., by various Authors.

M. LEUCADENDRON, Linn.

This species, as far as our knowledge goes, we regard as extra-Australian.

M. MINOR, Sm. (*M. cajuputi*, Roxb.)

This species also for the same reason should be regarded as extra-Australian.

M. CUNNINGHAMI, Schau.

This species is placed by Bentham in Fl. Austr., iii, 143, (*loc. cit.*) under *M. leucadendron*, Linn., but the original locality and description (Walp. Rep. ii, 927) show conclusively that it is *M. viridiflora*, Solander.

From this it would appear that Schauer had not access to the British Museum drawings and descriptions.

M. SALIGNA, Schau.

This is described by Schauer in Walp. Rep., ii, 927, and the locality is the same as *M. Cunninghami*—Endeavour River. It is therefore tropical, and from a drawing of the original by Dr. Daydon Jackson, London Linnean Society

sent to us, is different from any we have yet seen. (See excerpt of article by Mr. W. S. Campbell, *supra.*)

M. MAIDENI, R. T. B., Proc. Linn. Soc., N.S.W., 1913.

This is commonly known as the "Broad-leaved Tea Tree" throughout its geographical distribution, although at Port Macquarie it is known as the "Bell Bowery Tea-tree." It grows to a large size and produces an excellent pale, hard close-grained timber suitable for boat-building, carriage and general cabinet work, and is also very durable in the ground.

M. SMITHII, R. T. B., Proc. Linn. Soc., N.S.W., 1913.

This is commonly known as the "Broad-leaved Tea Tree" throughout its geographical distribution. It also, like *M. Maideni* grows to a large size and produces an excellent pale, hard close-grained timber, suitable for boat-building, carriage and general cabinet work, and is also durable in the ground, but has a well marked or pronounced sapwood.

From amongst the material collected at this Institution in connection with the species of Linnæus, we have separated these two forms, which we cannot place with any of the species here enumerated (*infra*), and these have been systematically described by one of us in the Proc. Linn. Soc., N.S.W., September, 1913, under the name of *M. Maideni* and *M. Smithii.*

M. VIRIDIFLORA, Soland.

This name first appears in Gaertn. Fruct. i, 173, (1788), under *M. angustifolia*, Gaertn., to which Bentham, Flora Australiensis, Vol. III, p. 142, gives specific rank. Index Kewensis synonymises the name under *M. angustifolia*, Gaertn., but this is without doubt an error, for in Britten's Botany of Cook's Voyages, published by the British Museum in 1901, an original drawing of *M. viridiflora*, Sol. is reproduced. This and the accompanying text prove conclusively it is not *M. angustifolia*, Gaertn., which is also figured in

the same work. Neither is it *M. leucadendron*, Linn. The original locality (*loc. cit.*) is Bustard Bay, Endeavour River, and some fine specimens of it are extant in the Sydney Herbarium, with leaves measuring up to 7″ long and 3″ wide, being identical with that portrayed in Britten's reproductions. The leaves are the broadest and most coriaceous of all the Melaleucas known to us.

There can be no doubt that it is a distinct species, and the name should stand.

Recently, there has been a species named from New Caledonia by Brongniart and Gris as *M. viridiflora*. By the law of priority this name must give place to that of Solander, as the tree, judging from specimens in the Sydney Botanic Garden Herbarium from New Caledonia under this name are certainly not the true *M. viridiflora* of Solander. The New Caledonian specimen should be given a new name.

M. lanceolata, R. Br. and *M. Sieberi*, Schau. are the *M. leucadendron* var. *parvifolia* of Bentham (*loc. cit.*).

As a result of these investigations, and an examination of material in the Sydney and Melbourne Herbaria, we find the valid species now to stand as follow:—

M. leucadendron, Linn.
M. minor, Sm (syn. *M. cajuputi*, Roxb.)
M. saligna, Blume.
M. Maideni, R. T. Baker.
M. Smithii, R. T. Baker.
M. viridiflora, Soland.
M. lanceolata, R. Br.

V. Range of Species.

M. LEUCADENDRON, Linn.—Extra-Australian, although it is possible that this species may occur around the tropical shores of the Continent.

M. MINOR, Sm.—East Indies and so is not Australian.

M. VIRIDIFLORA, Soland—Tropical shores of Australia.

M. VIRIDIFLORA, Brong. et Gris. (see note) New Caledonia.

M. CUNNINGHAMI, Schau.—Identical with *M. viridiflora*.

M. SALIGNA, Schau.—Mouth of tropical rivers of N.W. and N. Coasts.

M. MAIDENI, R. T. B. *M. leucadendron*, var. *lancifolia*, Bail.—Casino, Port Macquarie, Brisbane and well North.

M. SMITHII, R. T. B.—Port Jackson, Terrigal, Gosford.

M. LANCIFOLIA, Turcz.—Philippine Islands.

M. CUMINGIANA, Turcz.—Philippine Islands.

M. LANCEOLATA, R. Br. (Herb.) (*M. Sieberi*, Schau.)—Neighbourhood of Port Jackson.

VI. Chemistry of Essential Oils.

(*a*) "Cajuput" from MELALEUCA MINOR.

This oil which was sent to us by Dr. M. Treub, of the Royal Botanic Gardens, Buitenzorg, Java, was labelled "KAJOEPOETIH-OLIE." The oil was in appearance and odour identical with that of ordinary "cajuput" of commerce. It had a distinct green colour, due entirely to the presence of copper; the copper was removed and determined as such. The odour of cineol was most marked, and the secondary odour of the oil had a strong resemblance to that of terpineol. The crude oil had the following characteristics:—

Specific gravity at 15° C. = 0·9198.
Rotation $\alpha_D = -2{\cdot}4°$
Refractive index at 22° C. = 1·4666.
Saponification number = 5·46.
Cineol, determined by resorcinol method, = 68 per cent.
Soluble in $1\frac{1}{4}$ volumes of 70 per cent. alcohol by weight at 20° C.

On rectification, the first portion contained some aldehyde, strongly indicating valeric aldehyde, but benzaldehyde was not detected. The lower boiling terpenes were lævo-rotatory. Below 195° C. (Corr.) 77 per cent. distilled. This portion boiling between 215 – 260° (15 per cent.) was slightly dextro-rotatory, the rotation $\alpha_D = +0{\cdot}5°$, the sp. gr. = 0·9237, and refractive index at 22° = 1·4875.

These results agree with those usually recognised for "cajuput" oil, and do not agree with those obtained with the oils of the supposed forms of *Melaleuca leucadendron* growing in New South Wales and Southern Queensland, showing that these latter trees are not identical with the Melaleuca which supplies the well-known "cajuput" oil. The above investigation was carried out for comparison.

(b) MELALEUCA MAIDENI.

This tree which occurs in Northern New South Wales and in Southern Queensland, is that known in Queensland as *M. leucadendron* var. *lancifolia*, and the oil has been distilled in small quantities from the leaves of this species by Mr. Ingham of Brisbane; a sample distilled by him was analysed by Mr. R. C. Cowley, F.C.S., the results being published in the "Chemist and Druggist" of 28th May, 1910. We have investigated the oil of this tree from the following localities, and three several times of the year.

Port Macquarie, New South Wales, 30/11/1910.
Casino, New South Wales, 27/12/1911.
Port Macquarie, New South Wales, 15/1/1912.

The oils from these three specimens agree very well in general characters; this can be seen from the following table. The material was cut as for commercial oil distillation.

Crude Oils.	Yield per cent.	Sp. gr. at 15° C.	Cineol per cent.	Solubility in Alcohol by Weight.	Rotation a_D	Sap. No.	Refractive index.
Port Macquarie (1910)	1·79	0·9199	39	7 vols. 70%	$-4°.2$	3·8	1·4744 at 23°
Casino (1911) ...	1·26	0·9227	26	1 vol. 80%	$-0°.7$	3·2	1·4800 at 22°
Port Macquarie (1912)	1·17	0·9234	31	1 vol. 80%	$-1°.9$	5·1	1·4769 at 23°

Mr. Cowley's figures for his sample of oil of this species were:—Sp. gr. 0·922; Rot. $a_D = -3°$; ref. ind. 1·4623; cineol 45 per cent.

The crude oil of this species was but little coloured. As the leaves were distilled from iron the oil was not green,

and did not, of course, contain copper like ordinary "cajuput" oil. The odour reminds somewhat of "cajuput" but the secondary odour is distinctive. It contains much less cineol than ordinary "cajuput." The lower boiling terpenes consist principally of lævo-rotatory pinene and lævo-rotatory limonene. Some aldehydes were present in the first portion distilling, and the odour of benzaldehyde was easily detected. The high boiling fraction contained a considerable quantity of an alcohol, but the indications for the presence of terpineol were not good, particularly as only a small amount distilled between 190 – 255° C. After the latter temperature, a considerable quantity distilled, ranging from 30 to 40 per cent. of the total oil. This high boiling fraction apparently contains a fair quantity of the sesquiterpene alcohol which is such a pronounced constituent in the oil of the Sydney form, (*M. Smithii*). The dextro-rotation of this high boiling fraction, its high boiling point, together with the ascertained presence of an alcohol, indicate that this is so, although the physical results suggest the presence also of a sesquiterpene belonging to the closed chain series.

The sample from Port Macquarie (30/11/10) was rectified; a small amount of acid water and some aldehydes came over below 157° C. Between 157 – 173° C. 26 per cent. distilled; between 173 – 183° 38 per cent. The thermometer then quickly rose to 250°, only 1 per cent. distilling. Between 250 – 270° 30 per cent. distilled. The three main fractions gave the following results:—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 22°C.
First fraction	0·8914	– 5°.8	1·4628
Second fraction	0·9005	– 10°.4	1·4632
Third fraction	0·9257	+ 11°.2	1·4956

The cineol was determined by the resorcinol method in a portion boiling below 190° C., the result indicating 39 per

cent. of that constituent in the crude oil. The saponification number for the ester plus the free acid was 3·8.

The low boiling portion was repeatedly shaken with 50 per cent. resorcinol to remove the cineol, the residue well washed, dried and redistilled.

Between 157 – 132° C. 6·5 cc. were obtained, and between 162 – 175° 10 cc. distilled. These gave the following results:—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 20°C.
First fraction	0·8605	– 9°.2	1·4684
Second fraction	0·8603	– 18°.6	1·4701

These fractions were again rectified and 5 cc. obtained, distilling below 158° C.

This portion had rotation a_D – 7°.6; and refractive index at 20° = 1·4683. The nitrosochloride was prepared with it and this melted at 103 – 4°. It is thus evident that the pinene is lævo-rotatory, although less so than is the limonene.

The results obtained with the high boiling fraction suggest that a sesquiterpene is present in some quantity, although its identity remains at present undetermined.

The oil obtained from the Casino material was also rectified, the results being in close agreement with those given by the Port Macquarie sample. The high boiling fraction was, however, somewhat larger in amount (43 per cent.) and no less than 35 per cent. distilled above 265° C. This high boiling fraction had specific gravity at 15° = 0·9355; rotation a_D + 11°.1, and refractive index 1·4959. The somewhat smaller amount of eucalyptol (26 per cent.) in this oil is due to this increased amount of the high boiling fraction.

The oil from the Port Macquarie (15/1/12) material was also rectified, the fractions, together with their physical

characters, being in close agreement with those obtained with the other two samples above. The high boiling fraction (35 per cent., 30 per cent. distilling above 265° C.) had rotation $a_D + 16°.6$, specific gravity at 15° = 0·9412 and refractive index 1·4971. The cineol present in the crude oil was 31 per cent.

The saponification number of the ester by boiling was 5·1, while that of the acetylated oil, after boiling two hours with acetic anhydride and sodium acetate in the usual way, was 42·4. Assuming that the alcohol of the original ester was identical with the free alcohol, there was 16·8 per cent. of a sesquiterpene alcohol ($C_{15}H_{26}O$) in this sample of the crude oil of this species, and from the figures given above, this alcohol is assumed to correspond to that occurring so plentifully in the oil of *M. Smithii.*

(c) MELALEUCA SMITHII.

This is the common broad leaved Melaleuca growing in the neighbourhood of Sydney, Gosford, Terrigal and surrounding districts. How much further north of the last locality it extends is not yet known, but its southern limit is not much below Sydney.

We have investigated the oil of this tree from three localities, and the results thus obtained agree very well with each other, but differ considerably from those of the northern form (*M. Maideni*) and show no resemblance to "cajuput" oil, as can be seen from the following.

Locality.	Yield per cent.	Sp. gr. at 15°	Cineol per cent.	Solubility in Alcohol by Weight.	Rotation a_D	Refractive index at 22°	Sap. No.
Rose Bay, Sydney 18/12/1911.	0·607	0·8815	about 1	1·7 vols. 70%	+11°.8	1·4812	3·1
Terrigal, N.S.W. 21/12/1911.	0·923	0·9003	less than 2	2 vols. 70%	+6°.7	1·4824	3·3
Gosford, N.S.W. 20/9/1899.	0·495	0·8976	about 5	2 vols. 70%	+5°.8	1·4806	6·5

The cineol was determined by the resorcinol method in the portion distilling below 260° C. (15 per cent.) of the Gosford sample, but when calculated for the crude oil showed that not more than 5 per cent. of that constituent was present. The reactions for cineol were readily obtained in this portion of the oil. With the other samples (Rose Bay and Terrigal) a smaller amount distilled below 265°. The other constituents in the oil do not appear to be absorbed by resorcinol, and not more than 2 per cent. of cineol in the Terrigal and less than that in the Rose Bay oil was determined to be present by this method. That a little cineol was present was shown by the first portion giving the reaction for that substance with bromine. The terpenes were a little more pronounced in the Gosford sample, and this may perhaps be accounted for by the distillation of the leaves not having been carried so far as with the others, this is suggested also by the lesser yield of oil. The aldehydes obtained in the first portions distilling always contained a substance with the odour of benzaldehyde, and to endeavour to locate this, a portion of the crude oil was frequently agitated during two days, with a solution of acid sodium sulphite. A very small amount of a crystalline substance separated, which was collected with difficulty. When decomposed with soda a marked odour of benzaldehyde was obtained, but the amount available was too small to proceed further. It may be assumed, however, that benzaldehyde is the aldehyde having this odour occurring in the oil of this Melaleuca. The small amount of terpenes in the oil of this species consists of lævo-rotatory pinene, lævo-rotatory limonene and dipentene, thus agreeing in this respect with those found in the oil of *M. Maideni.* They were both determined in the oil of the Gosford sample.

The sesquiterpene alcohol. The principal constituent in the oil of this species is a liquid sesquiterpene alcohol, which, from its physical characters and properties, appears

to belong to the aliphatic series. The odour is somewhat pleasant, although weak in this respect. When diluted with alcohol and spread thinly on a watch glass, the odour becomes a little more defined and delicate and remains persistent for several days.

This appears to be the first time that a substance of this nature has been noticed occurring in the leaf oils of plants, and it is only very recently that similar constituents have been determined as existing in the odoriferous oils of certain flowers. In "Die ätherischen Öle" of Gildemeister and Hoffman, 2nd edition, p. 416, these substances are referred to, and the statement is there made that up to the present time (1910) they have only seldom been observed, but it is presumed that with extended investigations they will be more frequently found. Two of these alcohols are mentioned in the work referred to, *Nerolidol*[1] found in the higher boiling portions of Orange flower oil, which had, boiling point 276 – 277°, 128 – 129° (6mm.); spec. gr. 0·880; rotation $a_D + 13^{\circ}.32$; and *Farnesol* which occurs in the oil of Ambrette seeds, in Linden flower oil, in the oils of the flowers of various kinds of Acacias, and probably also in Rose oil. Haarmann and Reimer,[2] show the boiling point to be 160° (10 mm.); sp. gr. at 18° 0·885; n_D 1·488; rotation $a_D + 0^{\circ}$. An investigation has just been undertaken by M. Kerschbaum on farnesol.[3] This author assumes that farnesol acts as a fixing material for the more volatile constituents of the flower, and attributes the sweet scent of Linden flowers to the presence of these sesquiterpene alcohols, which delicate odour is brought out by extreme dilution assisted by the oxidising influences of the air.

[1] Hesse and Zeitschel, Journ. f. prakt. Chem. II, 66 (1902), 504.

[2] Patent No. 149603 and Chem. Zentralbl. 1904, I, 975.

[3] Ber. Deut. Chem. Gesell., 1913, p. 1732.

He suggests the following formula for farnesol, which it will be seen is an extension to the geraniol grouping:—

$$\begin{array}{llll} CH_3 & & \vdots & \\ & >C:CH.CH_2.CH_2.\underset{\displaystyle CH_3}{C}:CH.CH_2 & \vdots - & CH_2.\underset{\displaystyle CH_3}{C}:CH.CH_2OH. \\ CH_3 & & \vdots & \end{array}$$

Harries and Haarman (Ber. 1913, p. 1737) have also investigated the structure of farnesol by oxidation with ozone, and agree with the above formula.

It will be seen that farnesol does not contain an asymmetric carbon atom, and is thus inactive. The alcohol in the leaf oil of *Melaleuca Smithii* is dextro-rotatory, so that the molecule contains an asymmetric carbon atom, and thus must be a different substance to farnesol. The characters recorded for nerolidol (above) appear to agree more closely with those so far obtained with the alcohol from the oil of this Melaleuca. The difference in molecular structure between these substances may perhaps correspond to that between geraniol and linalool, as a tertiary carbon atom appears to be present, but considerable work is necessary to be carried out with this alcohol before its characteristics and its molecular structure can be ascertained; and we know very little, as yet, about the molecule of *nerolidol*.

We propose the name *melaleucol* for the dextro-rotatory aliphatic sesquiterpene alcohol which occurs in the leaf oil of this species of Melaleuca.

Melaleucol is an almost colourless, slightly viscous oil, with a weak, but somewhat pleasant odour. When dissolved in chloroform, or in glacial acetic acid, it takes up a large amount of bromine, and is thus highly unsaturated. This was also shown by the permanganate reaction.

So far, no satisfactory combination with this alcohol has been obtained, so that it has not yet been isolated in a perfectly pure condition. When freshly extracted from

the leaf it boils under atmospheric pressure at 275 – 277° C. with scarcely any decomposition, but the older oil splits off water more readily. Under reduced pressure the main fraction boiled at 163 – 165° at 33 mm.

Analysis gave the following results:—0·1855 gram. gave 0·5526 gram. CO_2 and 0·1936 gram. H_2O. C = 81·24 and H = 11·6 per cent. $C_{15}H_{26}O$ requires C = 81·08 and H = 11·71 per cent.

The specific gravity of the directly distilled alcohol, boiling within one degree of temperature, was 0·886 at 15° C. and the refractive index at 20° = 1·488. These figures roughly indicate a molecular refraction corresponding to that required for a sesquiterpene alcohol with three double linkings. The essential oil of this Melaleuca is thus shown to differ in constituents from that of any other species of Melaleuca so far determined, and consequently the product of this tree promises to be of considerable scientific interest, and possibly of commercial value. Further work will now be done upon it.

Rose Bay Trees (18/12/1911).

The sample of oil from the Rose Bay material was but little coloured, being of a light lemon-yellow. The odour had no resemblance to that of "cajuput," being somewhat delicate and perhaps characteristic.

Although somewhat viscid in character, and consisting almost entirely of high boiling constituents, yet, the specific gravity of the crude oil was exceptionally low. The yield of oil from the leaves with terminal branchlets was 0·61 per cent. The crude oil had

Specific gravity at 15° C. = 0·8815.
Rotation a_D = + 11°.8.
Refractive index at 22° = 1·4812.
Soluble in 1·7 volumes 70 per cent. alcohol by weight.
Saponification number for ester and free acid = 3·04.

On rectification under atmospheric pressure, only 2 per cent. distilled below 265° C. This portion contained, besides some water, a little aldehyde (in which the odour of benzaldehyde was readily detected), a very little cineol and some terpenes. Between 265 – 273° C. only 2 cc. distilled; but between 273 – 277° no less than 70 per cent. distilled, and between 277 – 280° 12 per cent. more came over. The last two fractions gave the following results:—

	Sp. gr. at 15°C.	Rotation a_D	Ref. ind. 23°C.
Fraction (265 – 277°)	0·8882	+ 9°.7	1·4830
Fraction (277 – 280°)	0·8937	+ 12°.4	1·4876

A portion of the crude oil was boiled with acetic anhydride and anhydrous sodium acetate for $1\frac{3}{4}$ hours in the usual way, well washed and dried. 1·5732 gram. required 0·2184 gram. KOH. so that the saponification number from this was 138·8; representing 55 per cent. of an alcohol ($C_{15}H_{26}O$). Another acetylated sample of the oil gave corresponding results. More than half the oil thus consisted of this sesquiterpene alcohol. Probably the greater portion of the remainder of the oil consisted of the corresponding sesquiterpene to this alcohol; this is suggested from the figures for specific gravity, boiling point, etc., so far obtained. It also seems as if the sesquiterpene has a higher rotation than has the alcohol. This will be proved later.

Terrigal Trees (21/12/1911).

The sample of oil from the Terrigal material (60 miles north of Sydney), was identical in appearance, colour, and odour with that from Rose Bay, and it had the same slight viscous behaviour. The yield of oil from the leaves and terminal branchlets was 0·923 per cent. This is higher than that obtained from the Rose Bay material, perhaps due to a difference in the age of the trees, or to location. A somewhat larger amount of terpenes was present in this oil, as was found also to be the case with the oil from

the Gosford material. The crude oil gave the following results:—

Specific gravity at 15° C. = 0·9003.
Rotation a_D = + 6°.7.
Refractive index at 23° = 1·4819.
Soluble in two volumes 70 per cent. alcohol by weight.
Saponification number for ester and free acid = 3·3.

The lower dextro-rotation in this oil is due to the larger amount of lævo-rotatory terpenes (pinene and limonene) in this oil than in that from the Rose Bay material, thus neutralising to a certain extent the dextro-rotation of the alcohol.

On rectification, two per cent. came over below 183° C.; this consisted of water, aldehydes (benzaldehyde distinctly noticed) cineol and terpenes. Between 183 – 265° 9 per cent. distilled. The terpenes were proved in the Gosford material to consist of lævo-rotatory pinene and lævo-rotatory limonene and dipentene. Between 265 and 274° 10 per cent. came over, and between 274 – 277° no less than 56 per cent. distilled. (This fraction consisted largely of the sesquiterpene alcohol characteristic of this species.) Between 275 – 280° 15 per cent. distilled. These fractions gave the following results:—

	Sp. gr. at 15° C.	Rotation a_D	Ref. index at 22°C.
First fraction	0·8702	– 19°.4	1·4719
Second fraction	0·8980	+ 6°.9	1·4834
Third fraction	0·9074	+ 12°.6	1·4871
Fourth fraction	0·9075	+ 7°.4	1·4898

A portion of the crude oil was boiled for two hours with acetic anhydride and sodium acetate in the ordinary way, and the acetylated oil prepared as usual. 1·5316 gram. required 0·1624 gram. KOH, therefore the saponification number = 106·04, representing 42 per cent. of an alcohol ($C_{15}H_{26}O$). Thus nearly half this oil consisted of this

aliphatic sesquiterpene alcohol. As with the Rose Bay oil the highest boiling portions gave indications for the presence of a sesquiterpene corresponding to that of the alcohol.

Gosford Trees (20/9/1899).

The sample of oil from the Gosford material (a few miles from Terrigal) was identical in odour, colour and appearance with those from Terrigal and Rose Bay. It approached more closely in constituents to the Terrigal sample, and this might be expected from the somewhat close proximity of these two localities. This sample of oil had been distilled fourteen years, but beyond a few preliminary tests nothing had been done with it. Although stored for such a long time in the Technological Museum, yet, it apparently had undergone little alteration, and the figures here given are in conformity with those of the other samples which were freshly distilled. It will be seen that this oil differs greatly from that of *M. Maideni* and does not agree at all with ordinary "cajuput." The terpenes in the lower boiling portion were lævo-rotatory pinene, lævo-rotatory limonene and dipentene. Benzaldehyde was also detected by the odour in the portion first distilling. Cineol was present but only about 5 per cent. in the crude oil; it was determined by the resorcinol method in the portion distilling below 260°. The crude oil gave the following results:—

Specific gravity at 15° C. = 0·8976.
Rotation $a_D = + 5^\circ.8$.
Refractive index at 22° = 1·4806.
Soluble in two volumes 70 per cent. alcohol by weight.
Saponification number for ester and free acid = 6·5.

On rectification, 2 per cent. of water, aldehydes, terpenes and cineol, came over below 173° C. Between 173–183° 8 per cent. distilled; between 183–193° 6 per cent. distilled; the thermometer then rose rapidly to 260° with only 1 per cent. more (this 7 per cent. thus forming one fraction).

Between 260 and 270° only 8 per cent. came over, but between 270 – 277° no less than 65 per cent. of the total distilled, 73 per cent. thus forming the third fraction. These fractions gave the following results :—

	Sp. gr. at 15°C.	Rotation α_D	Ref. ind. at 22°C.
First fraction (8%)	0·8768	– 14°.5	1·4679
Second fraction (7%)	0·8784	– 19°.6	1·4720
Third fraction (73%)	0·9028	+ 11°.6	1·4851

To obtain sufficient of the lower boiling constituents for determination, another 100 cc. were rectified with the above results. The amounts distilling below 260° (30 cc.) were added together, the cineol determined, and the remainder, with the unabsorbed portion, distilled to 177° C. The cineol was removed from this by repeated agitation with 50 per cent. resorcinol, the unabsorbed portion washed and dried. On again distilling, about half came over between 155 – 162°, another fair portion between 170 – 177°. With these the following results were obtained:—

	Sp. gr. at 15°C.	Rot. α_D	Ref. ind. at 24°C.
First portion (155 – 162°)	0·8604	– 10°.6	1·4668
Second portion (170 – 177°)	0·8534	– 20°.1	1·4718

The nitrosochloride was prepared with the first portion and this when finally purified melted at 103–4°, pinene was thus present. The tetrabromide was formed with the second portion and this when purified from acetic-ether melted at 118 – 119 thus indicating dipentene as well as lævo-limonene.

There were thus shown to be present in this oil about 5 per cent. cineol, about 6 per cent. pinene, and about 4 per cent. limonene, the remainder consisting largely of the aliphatic sesquiterpene alcohol, while the presence of the corresponding sesquiterpene was also indicated.

A portion of the crude oil was boiled two hours with acetic anhydride and sodium acetate in the usual way, and the acetylated oil determined. 1·5371 gram. required 0·1764 gram. KOH giving 115 as the saponification number. This represents 45·6 per cent. of a sesquiterpene alcohol. Thus nearly half the crude oil of this sample consisted of the alcohol characteristic of this species of Melaleuca.

We are indebted to Dr. B. Daydon Jackson, F.L.S., of the London Linnean Society, and Dr. M. Treub of Java, for assistance and material. Also to Mr. J. H. Maiden, F.L.S., and Prof. A. J. Ewart, D.Sc., for kindly permitting us to examine material in the Sydney and Melbourne Herbaria respectively.

ON A NEW SPECIES OF EUCALYPTUS FROM NORTHERN QUEENSLAND.

By J. H. Maiden, F.L.S., and R. H. Cambage, L.S., F.L.S.

[*Read before the Royal Society of N. S. Wales, December 3, 1913.*]

Eucalyptus Brownii, nov. sp.

Box-tree mediocris, circiter 40′ alta, erecta magis quam dependens. Cortex dura, lamellosa. Folia juvenilia lanceolata vel angusto lanceolata. Folia matura lanceolata, 10 – 15 cm. longa 2 – 3 cm. lata, venis lateralibus angulo 30° ad costam mediam.

Alabastri parvi, clavati, operculum hæmisphæricum, umbella quaque 3 – 9 in capite. Fructus parvi, conoidei, circiter 3 cm. diametro.

We propose the name in honour of the great Robert Brown who (amongst other parts) is closely identified with the botany of Northern Queensland.

A medium sized Box-tree, about 40 feet high, erect rather than drooping.

Bark. Hard thin flaky Box-bark, on the trunk and large branches, the ultimate branchlets smooth.

Juvenile leaves. Lanceolate or narrow lanceolate. Generally long and narrow, petiolate, equally green on both sides, and slightly shiny, venation distinct, spreading, intra-marginal vein distinct from the edge. Size say 20 × 2 cm.

Mature leaves. Lanceolate; except as regards the size, the description of the juvenile leaves applies. Size say 10 – 15 × 2 – 3 cm. Lateral veins arranged at angle of about 30 degrees with midrib.

Buds small, clavate, operculum hemispherical or slightly umbonate, and about half the length of the calyx-tube, which tapers gradually into the pedicel.

Flowers. Inflorescence paniculate, the individual umbels three to nine in the head.

Anthers semi-terminal, nearly globular in shape, opening in small pores on each side near the top. Filament at the base, small gland on the top.

Fruits. Fruits small, conoid, about 3 cm. in diameter and the calyx-tube about the same length, tapering, not perfectly gradually, into the pedicel, rim thin, tips of the valves flush with the orifice, which is not constricted.

Habitat. Type from Reid River near Townsville. (N. Daley, Sept. and Dec., 1912.)

Wirra Wirra, Almaden to Forsayth, North Queensland, growing on a somewhat sandy-conglomerate formation which furnishes a more siliceous soil than that usually selected by Box trees. (R. H. Cambage, No. 3895, August, 1913).

Synonyms.

E. bicolor, A. Cunn. var. *parviflora*, F.v.M., Burdekin River (see B. Fl. iii, 215) *E. populifolia*, F.v.M. non Hook.

Scrub Box tree of the Burdekin River, but not the Box tree of the Suttor River, labelled as above, which is *E. populifolia*, Hook.

All the above specimens were examined by Mueller, and apparently by Bentham also.

Affinities.

Its closest relations are with two species—*E. populifolia* Hook. and *E. bicolor*, A. Cunn. Both are indicated by the labels of both Bentham and Mueller.

1. With *E. populifolia*, Hook. To the typical form of *E. populifolia* the resemblance is not close, but there is a narrow leaved form of the species to which the resemblance is closer. The differences lie in the bark, which is less flaky in *populifolia*, in the more conical fruits of *E. Brownii*,

and particularly in regard to the position of the intra-marginal vein, which is much more removed from the leaf-edge in *E. Brownii.*

2. With *E. bicolor*, A. Cunn. The differences appear to be the duller colour of the foliage of *E. bicolor*, that of the new species being a vivid green, its less spreading venation, and less conoid fruits. *E. Brownii* has not the weeping habit of *E. bicolor.*

There is a specimen in the Melbourne Herbarium labelled "near Mount Elliott, Queensland, Fitzalan and Dallachy" which appears to be *E. Brownii.* The late J. G. Luehmann has a note "Placed by Bentham with *E. largiflorens (bicolor)* seemingly with injustice F. v. Mueller."

NOTES ON EUCALYPTUS, (WITH DESCRIPTIONS OF NEW SPECIES) No. II.

By J. H. Maiden, F.L.S.

[*Read before the Royal Society of N. S. Wales, December 3, 1913.*]

I have the honour to submit the following proposed new species :—

1. *E. hœmatoxylon*, Maiden;
2. *E. Jacksoni*, Maiden;
3. *E. Mooreana* (W. V. Fitzgerald) Maiden;
4. *E. mundijongensis*, Maiden;
5. *E. penrithensis*, Maiden;

a new variety:—*E. marginata*, Sm. var. *Staerii;* together with some miscellaneous notes referring to the genus.

As regards No. 3, Mr. Fitzgerald collected it and indicated that it was new, but he did not describe it. I am responsible for the description.

No. 1. Eucalyptus hæmatoxylon, nov. sp.

Arbor parva altitudinem 20′ et trunci diametrum 18″ attinens, "Mountain Gum" nominata. Bloodwood typicus. Cortex stratis mollibus rubris secedens. Lignum rubrum, gummi venis. Folia petiolata lanceolata ad lato-lanceolata, coriacea, 8 – 9 cm. longa, 2 – 3 cm lata. Venæ secundariæ tenues et fere paralleles. Flores in corymbo irregulare. Filamenta alba. Fructus ovoidei vel fere sphærici, aliquando orificio constricti, urceolati, 3 cm. longi, 2·5 cm. lati. Orificium 1 cm. latum.

A small tree, attaining a height of 20 feet and a trunk diameter of 18 inches. "Much resembling *E. calophylla*, R. Br., the "Red Gum," in general appearance." Known as "Mountain Gum." It is a typical "Bloodwood."

Bark. In soft reddish flakes, typically that of a "Bloodwood."

Timber. Red, with gum-veins, stated to be "very soft"; a typical Bloodwood timber, hence the specific name suggested.

Juvenile leaves. Broadly lanceolate, thin-membranous, reddish-purple, petiolate, margin thickened, secondary veins very fine and nearly parallel to each other. Containing caoutchouc.

Mature leaves. Petiolate, lanceolate to broadly-lanceolate, symmetrical or somewhat oblique, apex attenuate-acuminate, coriaceous and of medium thickness, equally green on both sides, margin thickened, intramarginal vein not far removed from the edge. Secondary veins fine and nearly parallel to each other. Length say 8 or 9 cm. and breadth 2 – 3 cm.

Buds. In an irregular corymb, not seen in a young state; after the opercula have fallen off the calyx-tube is somewhat urceolate.

Flowers not seen by me, but stated to have white filaments.

Fruits. Ovoid to nearly spherical, sometimes constricted at the orifice, thus taking on an urceolate shape. Large, 3 cm. long and 2·5 cm. broad with an aperture of 1 cm. and less. Tips of valves well sunk. Seeds large, wing rudimentary.

Habitat. Happy Valley, Jarrahwood Railway, Western Australia. Generally in poor sandy country. Forest Ranger W. Donovan, July, 1912.

Affinity.

The affinity at once suggested is *E. ficifolia*, F.v.M., but the filaments of the new species are white, and the fruits are of a different shape, viz., smaller and more spherical, those of *E. ficifolia* being somewhat cylindroid. The seeds of the latter species also are winged, its bark is more fibrous and its timber paler; it lacks the rich cedar-coloured timber of the present species.

No. 2. Eucalyptus Jacksoni, nov. sp.

Arbor magnifica sylvae, altitudinem 200′ attinens, et 15′ diametro. "Red Tingle Tingle" vocata. Cortex "Stringybark" similis sed fragiliuscula. Lignum rubrum, durum. Folia juvenilia fere orbicularia vel lato-lanceolata. Folia matura petiolata, lato-lanceolata, acuminata, pleraque 9 cm. longa, 3 – 4 cm. lata. Venæ visibiles, non conspicuæ. Alabastros floresque non vidi. Fructus fere sphaerici, plerique 8 mm. ad 1 cm. diametro. Orificium parvum, 3 mm. diametro. Valvarum apices sub orificio valde depressi.

A noble forest tree up to 200 feet high, erect in habit, with a long trunk, which attains a diameter of fifteen feet

(measured at four feet from the ground). Another measured tree was 7 ft. 6 in. in diameter and 80 feet high (Mr. Saw). It reached a height of quite 200 feet; one tree measured was 45 feet round the base, 38 feet round six feet from the ground, and about 50 feet to the first branch (Mr. Brockman). Known locally as "Red Tingle Tingle."

Bark fibrous, reddish, thick, of a stringybark character, but somewhat brittle, covering the trunk and branches.

Timber. Bright red, reminding one, in that respect, of the Forest Mahogany of New South Wales (*E. resinifera*, Sm.). It is fissile and tough, and I believe it to be a most valuable timber for economic purposes.

Juvenile leaves. Nearly orbicular to broadly lanceolate, somewhat oblique, paler on the under side, not specially thin, venation distinct but fine, lateral veins nearly parallel, intramarginal vein well removed from the edge. Oil dots abundant. Average dimensions about 1 dm. long by 6 to 8 cm. wide.

Mature leaves. Equally green on both sides, petiolate, broadly lanceolate, acuminate, slightly curved, slightly inequilateral, veins obvious, but not very conspicuous, lateral veins parallel, intramarginal vein well removed from the edge, well besprinkled with fine oil dots, and apparently moderately rich in oil. Average size of leaves 9×3 to 4 cm.

Buds and flowers not seen.

Fruits. Almost spherical, with an average diameter of 8 mm. to 1 cm. with a small orifice of say 3 mm. in diameter. Tips of valves well sunk below the orifice.

Hab. Deep River, Nornalup Inlet, Bow River, Irwin's Inlet, South West Australia. (The type collected by Sidney Wm. Jackson). Found also on the hills along the Frankland River, where it predominates and extends about ten miles up. (Inspecting Ranger H. S. Brockman, to the Inspector General of Forests, W.A.)

Affinities.

1. With *E. Guilfoylei*, Maiden. Although there are precedents, I hesitate to describe a species in absence of inflorescence, and without this, the description must be incomplete. But I have no doubt as to the validity of the species. It is closely allied to the Yellow Tingle Tingle (*E. Guilfoylei*, Maiden),[1] the wood of which is pale, of a yellow colour and heavy, that of the present species being red, and lighter in weight.

The Red Tingle Tingle is a much larger and thicker tree than the Yellow Tingle Tingle, the latter having been observed only up to five feet in diameter.

As regards the adult leaves, those of *E. Guilfoylei* are always symmetrical or nearly so; those of the new species are more or less oblique, shorter and broader.

The oil dots in *E. Guilfoylei* are a greater distance apart than in the case of the new species, over the leaves of which they are evenly and abundantly diffused, while the secondary veins are further apart and ramify more in the case of the leaves of *E. Guilfoylei*.

2. With *E. patens*, Benth. Mr. H. S. Brockman says that "in general appearance the trees resemble very much the Blackbutt," (*E. patens*). Reference may be made to the original description of *E. Guilfoylei*, where there are some comparative references to *E. patens*.

No. 3. Eucalyptus Mooreana, (W. V. Fitzgerald) Maiden, nov. sp.

Arbor parva, contorta, glauca. Ramuli teretes. Folia juvenilia ovato-cordata vel lato-lanceolata, amplexicaula vel perfoliata, crassa, pleraque 10 cm. longa, 8 cm. lata. Venæ patentiores, venis secundariis fere parallelibus, vena peripherica a margine remota. Folia matura ampliora et acuminatiora. Opercula conica,

[1] *Journn. W. A. Nat. Hist. Soc.*, III, 180,

et longitudine et diametro 1 cm. metientia. Fructus hemisphærico-cylindroidei, valvarum apicibus conspicue exsertis.

In honour of Newton J. Moore, Minister for Lands, subsequently Premier, and now Agent-General in London for the State of Western Australia.

A small crooked tree, glaucous all over, branchlets round. Notes on bark and timber not available.

Juvenile leaves. Ovate-cordate or bluntly and broadly lanceolate, stem-clasping or perfoliate. Thick, somewhat undulate, uniform colour on both sides, venation somewhat spreading, the secondary veins roughly parallel. Intramarginal vein distant from the edge. Average size say 10 × 8 cm.

Mature leaves. These do not differ essentially from the juvenile leaves except that they are larger and more acuminate. Average size say 15 × 9 cm.

Buds. Four to seven on a sessile or nearly sessile head with a thick common peduncle of about 1 cm. Symmetrical, the operculum bluntly conical, about 1 cm. long and of equal diameter, the calyx-tube of equal length and with one or two angles.

Flowers. Pale yellow when fresh, drying orange red. Anthers long and creamy in colour, opening in parallel slits, large gland at the back, filament attached to the middle, versatile.

Fruits. Hemispherical-cylindroid with a thin, sharp, slightly domed rim, the tips of the valves very prominently protruded. Diameter at rim scarcely 1 cm.

Habitat. Summits of Mounts Broome, May; Leake, July; Rason, September, 1905; and Bold Bluff, all Lady Forrest and King Leopold Ranges, Kimberley, North-west

Australia (W. V. Fitzgerald). Collected during the Kimberley Survey Expedition.

Affinities.

1. With *E. perfoliata*, R. Br. Both have thick perfoliate leaves which generally resemble each other, but those of *E. perfoliata* are longer. The flowers and inflorescence are different, while the very large fruits which belong to the section Corymbosæ, and have sunk valves, are totally different.

2. With *E. alba*, Reinw. The fruits have something in common and also the juvenile leaves, which are however, petiolate in *E. alba*. The buds are very different. The mature leaves of *E. alba* are never so lanceolate as those of *E. Mooreana*. *E. alba* is a glabrous, soft large gum of moist flats, *E. Mooreana* is a crooked glaucous tree of mountain tops.

APPENDIX.—The name was used by Mr. Fitzgerald in the "Western Mail," Perth, W.A., of 2nd June, 1906. No description of the plant was ever published. A small scale photograph was accompanied by the following words:—"*Eucalyptus Mooreana*, W.V. F. is a new species occurring on the summits of Mounts Broome, Rason, Leake and Bold Bluff. It forms a small crooked tree, with usually mealy-white leaves and pale yellow flowers. It has been named out of compliment to the present Minister for Lands."

No. 4. EUCALYPTUS MUNDIJONGENSIS, nov. sp.

Early in 1909, Dr. J. B. Cleland gave me a photograph of a tree and a few fragments of fruits and leaves from Jarrahdale, Western Australia. His label was "near Jarrahdale. Fine adherent bark at base, top clean. Near Jarrahdale Forest."

I recognised the specimens as identical with leaves and fruits given me by the late Mr. J. G. Luehmann of the National Herbarium, Melbourne, many years ago, when I intended to visit Western Australia, a trip which was postponed. This specimen bore the label "Close to the inn near Jarrah Dale, about 28 miles from Perth, (Sir) John Forrest, 22nd March, 1882."

The locality is near Mundijong Railway Station. I have been in communication with Mr. C. R. P. Andrews of Perth on the subject, both before and since my visit to the Western State in 1909. Although I planned to visit the tree, and actually got as far as the Railway Station, I was compelled to return to Perth without inspecting it.

Mr. Andrews kindly communicated with the local teacher and the following are extracts from two of his letters:—

"The teacher (Mr. Stephen Wallace) states that the tree grows about five miles from Jarrahdale, and he therefore wrote to Mr. R. Cowen, on whose property the tree stands, for particulars. In forwarding the specimens, Mr. Cowen remarked, 'Suckers are not obtainable. As far as I know, the tree is the only one of its kind in the district, and it seems to me to be a great age. The diameter is about five feet, and the tree grows on poor shallow soil. The sub-soil is nearly pure pipe-clay, and it is in a very wet place, both in summer and winter. Local opinion generally classes it as a Tuart.'

"The teacher states that it is a difficult tree to get specimens from, except when high winds blow the branches off. He also states that it appears to be in danger of destruction from white ants."

Mr. Wallace, has kindly forwarded small sections of one of the smaller branches and also some twigs at Mr. Andrews' suggestion. For additional material, I am inbebted to Mr. H. M. Giles of South Perth.

When a tree is isolated, or very rare, there is a temptation to look upon it as hybrid, and I have considered that view in the present case. It may be a correct one, but I do not know enough about its parents to emphasise the point. I believe it should have a name, and although I have a fair knowledge of Western Australian Eucalypts, it seems quite distinct from any, imperfect as my material is. I propose the following name and description:—

E. mundijongensis, sp. nov.

Arbor alta. Cortex basi trunci dura et secedens. Rami teretes. Lignum pallidum. Folia circiter 15 cm. longa et 2 cm. lata, angusto-lanceolata, leniter falcata, nitentia, concoloria, crassa, coriacea, petiolata, penniveniis parum conspicuis. Alabastri in apicem acutati, clavati. Operculum in apicem acutatum circiter dimidio calycis tubo æquilongum. Flores non vidi. Fructus fere sessiles, cylindroidei, circiter 1·5 cm. longi et ·75 cm. diametro, margine angusta et sulcata. Valvarum apices sub orificio valde depressi.

A tall tree, about 80 – 100 feet high, and 5 feet in diameter about 4 feet from the ground. The trunk of the only specimen known at present leans somewhat and divides into two main branches of approximately equal diameter at about 25 feet from the ground.

Bark. "Fine adherent bark at base, top clean" (Dr. Cleland). Specimens of the bark forwarded by Mr. H. M. Giles and also by Mr. Wallace, are hard flaky, breaking off in long woody strips. Bark of smaller branches smooth, but exhibiting exfoliation. It has a good deal in common with the Peppermint barks of the Eastern States (e.g. *E. piperita*, Sm.)

Timber. Pale coloured.

Juvenile leaves. Coarse, thick, coriaceous, moderately shiny, equally green on both sides, petiolate, venation not very prominent, somewhat spreading at the base in some

specimens, in others at an angle of about 60 to the midrib and roughly parallel. Intramarginal vein not conspicuous, and somewhat removed from the edge. Size of leaves seen by me about 12 cm. long and 5 broad.

Mature leaves. Narrow lanceolar, somewhat falcate, shiny, equally green on both sides, thickish, coriaceous, petiolate, venation inconspicuous and penniveined, margins thickened, and the fine intramarginal vein not close to the edge. Leaves seen by me about 15 cm. long and 2 broad.

Buds. Not seen perfectly ripe. Pointed clavate, slightly angular, the operculum pointed, very slightly exceeding the calyx-tube in diameter, and about half as long as the same. Each half ripe bud about 1 cm. long, with a pedicel of half that length, apparently 3 to 7 buds in the umbel, with a strap shaped peduncle of 1.5–2 cm. Flowers not seen.

Fruits. With short peduncles to nearly sessile, cylindroid, about 1·5 cm. long and about half that in diameter, with a thin, grooved rim, valves 3 or 4, and the tips well sunk below the orifice.

Habitat. This has been already stated.

Affinities.

1. With *E. incrassata*, Labill. Mueller suggested this affinity on a label on Sir John Forrest's specimen.

The affinity is there, no doubt. We have it in the cylindroid fruits, but I know of none quite so cylindrical as those of the present species. As regards the buds, the operculum is shorter than the calyx-tube in some forms of *E. incrassata* also, but there is an absence of multiple ribbing in the present species. The juvenile leaves are somewhat different and the mature leaves are very different to those of any form of *E. incrassata* I know. The proposed species is a large tree, far exceeding in size that of any form of *E. incrassata* I ever heard of.

2. With *E. gomphocephala*, DC. "Local opinion generally classes it as a Tuart," (correspondent of Mr. Andrews). Figures of *E. gomphocephala* can be seen in the "Eucalyptographia" and at Plate 92, Part xxiv, of my "Critical Revision of the Genus Eucalyptus" in the press. The affinities are not close, the swelling of the operculum in *E. gomphocephala* is a very prominent character, and there is only the trace of a swelling observable in the buds of the new species (they are, however, unripe). Occasionally, *e.g.* at fig. 2 f. of the plate quoted, the rim of the fruit of *E. gomphocephala* may be reduced, in which case the fruit bears some resemblance to that of the new species. But it would appear that the fruit of *E. gomphocephala* always has exserted valves. The resemblance of the leaves is not specially close.

When I get flowers I will again raise the question of the affinities of this tree; in the absence of them, any conclusions must be of a provisional nature.

No. 5. Eucalyptus penrithensis, n. sp.

Arbor mediocris, "Bastard Stringybark" vocata. Cortex trunci dura et subfibrosa. Rami teretes. Folia matura crassuiscula, venis nitentibus, distinctis, patentibus, vena peripherica a margine remota. Alabastri stellulati, juvenes angulatuisculi, maturi clavatiores. Operculum conicum. Flores paniculati 4 – 10 in umbella quaque. Antherae reniformes. Fructus hemisphærici ad fere pilulares diametro circiter 5 mm. margine laevo et conspicuo. Fructus a pedicello filiforme acute disjuncti.

"Bastard Stringybark" or "Peppermint."

Two miles east of Penrith, N.S.W. (J.L. Boorman, January 1900). A tree of medium height and very scarce locally.

Bark hard fibrous on the trunk, branches smooth, intermediate in character between a "Stringybark" and a "Peppermint."

Timber reddish-brown and with concentric though not abundant gum-veins.

Intermediate leaves petiolate, falcate, acuminate, mostly unsymmetrical, rather coriaceous, equally green on both sides, venation prominent, spreading, intramarginal vein well removed from the edge. Average size say 13 cm. by 3 cm. broad.

Mature leaves much smaller, say 9 cm. by 1 cm. broad, rather thick, shiny, plentifully besprinkled with black dots, venation the same, resembling those of intermediate leaves.

Buds stellulate and somewhat angled when very young, more clavate as maturity approaches. Operculum conical, the calyx-tube tapering into a short pedicel.

Flowers. Paniculate, 4 to 10 in the individual umbel, which has a slightly flattened common peduncle under 1 cm. long. Anthers kidney-shaped.

Fruit hemispherical to nearly pilular, diameter about 5 mm. with a well defined smooth rim, tips of the valves either sunk, or not protruding beyond the orifice. The fruit is sharply separated from the filiform pedicel.

Habitat. As stated. The tree is said to also occur in the Liverpool district, but I have been unable to verify this.

Affinities.

This is an anomalous, rare and apparently local species, and one naturally looks upon it as a hybrid. At the same time hybridism is difficult to prove. Of course it is not necessary to prove that the assumed parents are to be found, at the present time, in close juxtaposition to the individuals from which one obtained material in the present case. The parents may be some distance away and the seed of the tree may have been conveyed in a number of ways. Possibly the parents are *E. eugenioides*, Sieb. and *E. haemastoma*, Sm. var. *micrantha*, Benth. Let us consider these in detail.

1. With *E. haemastoma*, Sm. var. *micrantha*, Benth. (A "White Gum"). The affinities lie in the smoothness of the branches, the fruits and the young (intermediate) leaves.

2. With *E. eugenioides*, Sieb., (A "Stringybark"). The bark indicates some affinity to the Stringybark, and there is also affinity in the foliage (as also with the White Gum). There is some (not close) resemblance, in the fruits, while the pedicellate fruit is seen in the White Gum.

In 1903 I received from Mr. R. H. Cambage "a form of *E. eugenioides*, Sieb." from between Tingha and Guyra, and in the following year visited the tree. I labelled it on 1st April, 1905, and again on 30th March 1906, "probably a *eugenioides-stellulata* hydrid," and I put it with my collection of reputed hybrids to be dealt with collectively in my "Critical Revision."

During the present year,[1] Mr. R. T. Baker has described it as a new species (*E. Laseroni*) and says it bears the local reputation of being a cross between *E. laevopinea* and *stellulata*.

We have also a species *E. oblonga*, DC., in "Prod. iii, 217," the type being Sieber's "Pls. Exs., No. 583." I have identified this with plants attributed to *E. eugenioides*, Sieb., in N.S.W. The buds are stellulate and the plant resembles that of *E. Laseroni*, and, to a less extent, in this respect, *E. Penrithensis*. There is no doubt that *E. eugenioides* may similate *E. stellulata* and the facts that I have accumulated should be added to and the taxonomic meaning of these affinities carefully gone into.

The question of the recognition of *E. oblonga*, DC., as a species distinct from *E. eugenioides*, Sieb., will require to be dealt with.

---

[1] *Proc. Linn. Soc. N.S.W.*, XXXVII, 585.

3. With *E. piperita*, Sm. Penrith is not in *E. stellulata* country, and the relations of the proposed new species with *E. piperita* may be examined. The barks resemble each other a good deal. The pointedness and curvature of the young buds reminds one of those of *E. piperita.* The resemblance of the foliage and anthers would apply more or less to *E. eugenioides*, *haemastoma* and *piperita.*

It is not possible to submit illustrations in the present case, and they are especially necessary when we make postulations about tree-hybrids; I can only say that they will be fully illustrated in those parts of my "Critical Revision of the Genus Eucalyptus" to be devoted to hybridisation.

Proposed New Variety.

E. marginata, Sm, var. *Staerii*, var. nov.

King River Road, near Albany, W.A. (J. Staer, August, 1911).

The fruits of the normal species, as figured by Mueller in the "Eucalyptographia," are depicted as 1.5-2 cm. long and 1·7 cm. broad and tapering somewhat into the thickened pedicel. I have received from Mr. J. Staer, specimens of *E. marginata* with fruits in the well-dried state rather more than 2 cm. long and broad, and not tapering into the pedicel. Some of the fruits have a well-defined rim. The foliage is coarser than that of the type, and this handsome, large fruited form is evidently a product of special environment.

Miscellaneous Notes.

(*a*) *E. aggregata*, Deane and Maiden (Black Gum).

This is conspecific with a Tasmanian tree, *E. Rodwayi*, Baker and Smith, "Papers and Proc. Roy. Soc. Tas.," 139, 1913. These gentlemen were partly misled by a statement made by me in 1902, working on imperfect material, that

the Tasmanian tree was identical with the allied *E. Macarthuri*, Deane and Maiden, which is incorrect. So far as we know, at present, *E. Macarthuri* does not exist in Tasmania.

(*b*) *E. decipiens*, Endl., and *E. concolor*, Schauer.
Not specifically different.

I have dealt with *E. decipiens* at p. 149 and *E. concolor* at p. 153, Part xiv of my "Critical Revision." At p. 154, I stated that I had not seen the type of *E. concolor*, and at p. 155 I drew attention to the unsatisfactoriness of the situation, so far as the relations of this species and *E. decipiens* are concerned. Schauer in Lehmann, "Plantæ Preissianæ," i, 129, gives the habitat etc., of the type of *E. concolor* as "In colle calcareo prope coloniam Freemantle December 1838 florens, Herb. Preiss. No. 225."

A specimen of the type, which seems to be excessively rare, is before me, kindly lent by Dr. Fischer von Waldheim, Director of the Imperial Botanic Garden of St. Petersburg. It bears the label "225, *Eucalyptus concolor*, Schauer, arbuscula 8 – 12 pedalis. In colle calcarea prope urbisculum Freemantle, Decbr. 24, 38, L. Preiss legit."

This typical *E. concolor* (from Fremantle of course) is identical with the specimens from the same locality enumerated in the last paragraph of p. 151 (*op. cit.*) with the exception that Mr. Fitzgerald's specimens are not so typical as the others. Continuing the examination further, I cannot find any important difference between these typical specimens of *E. concolor* and those enumerated by me at pp. 150, 151, under *E. decipiens* (I will refer to var. *angustifolia* presently).

Turning now to the specimens of *E. concolor* enumerated at p. 154, the specimens I there recorded as having been seen by me, are coarser and have the leaves somewhat thicker than those of the type.

To sum up, the variety *latifolia* of *E. decipiens* (see p. 149, *op. cit.*) is the specimen that I have seen as the type (of *E. decipiens*). It is figured at 1, Plate 63, and it includes all the *E. decipiens* (except var. *angustifolia*) together with all the *E. concolor* that I have seen.

I, therefore, propose to amalgamate the two species, and *E. decipiens*, Endl., is the older name (1837); *E. concolor*, Schauer, was described in 1844.

The only point in any way unsettled, in my opinion, is the anthers, which I described (as regards *concolor*) at p. 153, and commented upon at p. 155 (*op. cit.*). It would appear that the anthers in *E. concolor* are rather larger and with longer slits than in *E. decipiens*, and not so globular in shape, but in view of the more ample material now available, I believe it will be found that the variation in the anthers of *E. decipiens* is greater than was formerly believed to be the case.

The var. *angustifolia* of *E. decipiens* comes from Cape Riche, and in its typical form is certainly narrow leaved, but Endlicher himself says that the leaves are variable, and that is my experience. I refer to this form at p. 150 (*op. cit.*).

In Preiss' label on the specimen of No. 241 received from Dr. von Waldheim, the locality Wuljenup (see p. 149 "Crit. Rev.") is crossed out, and the locality "Konkoberup" (also at Cape Riche) substituted. For a note on this locality see p. 244, Part xviii, "Crit. Rev."

(c) *E. goniantha*, Turcz, and *E. diversicolor*, F.v.M.

Bentham (B. Fl. iii, 248) records *E. goniantha*, Turcz., from "Franklin (Frankland) River, Maxwell (in fruit only with rather broad leaves)." Mueller ("Eucalyptographia" under *E. diversicolor*) says that this specimen belongs to *E. diversicolor*.

(*d*) "A species in the making"—akin to *E. melanophloia*, F.v.M.

The making of species is going on all around us, but in regard to large trees, which do not produce seed until after the lapse of years, it is very rarely that we have the opportunity of tracing the parents except by inference.

I invite your attention to specimens of an Ironbark, Warialda, N.S.W., W. A. de Benzeville, 28th May, 1913.

Its foliage is pale coloured but not glaucous. Its juvenile foliage is of a paler green, with short petioles, broadly lanceolate, but very different to that of *E. melanophloia.*

We have been of course aware for many years how variable is the foliage of *E. melanophloia*, lanceolate leaved forms being well known. Particulars may be found in my "Critical Revision," Part xii, p. 71. But the present form is different to any that I have previously seen.

Although *E. melanophloia* is abundant in the district, Mr. de Benzeville reports that this form does not appear to grow in association with that species, but appears to be always associated with *E. crebra.* He also states that the timber is extremely brittle, and the bark is not furrowed as deeply as is usual with Ironbarks. The specimen forwarded to me shows a *crebra* looking bark and timber apparently not abnormal, but Mr. de Benzeville doubtless speaks of its local reputation. This form, as far as general morphological characters go, is intermediate between *E. melanophloia* and *E. crebra*, and it may have arisen from cross-polliniation, but that is surmise.

Owing to changes of environment, it is very often the case that we have "breaks," and in the present case, we may have a break from *E. melanophloia* in the direction of narrower, more petiolate leaves, with other minor differences.

Mr. de Benzeville's statement that "it does not appear to grow in association with *E. melanophloia*, but appears to be always associated with *E. crebra*," would seem to indicate that the plant is getting established as an independent entity, and being in unstable equilibrium itself, it may produce progeny still further departing from typical *E. melanophloia*.

I do not think the departure from type in the present case has proceeded far enough for me to indicate a new species, but we certainly have indications of a new species in the making, and these aberrant forms can only be usefully dealt with in a collective manner.

(*e*) *E. piperita*, Sm.

Upper Meroo, between Mudgee and Hill End, A. Murphy. Compare the western localities given in Part x, of my "Crit. Rev." p. 302. It is very scarce in the district. Less urn-shaped fruits than normal, leaves thicker. Timber of comparatively good quality, less veined than on the coast.

(*f*) *E. Planchoniana*, F.v.M.

Supplementing the notes of this not well-known species at p. 66, Part xxiv of my "Forest Flora of New South Wales," I desire to add "I have found it growing from Coff's Harbour to close to South Grafton, the range seems to be extensive. I have not found it growing off the gravelly (ironstone) ridges, and never on flat country. It attains a height of 60 to 70 feet, straight trunks; the matured trees are very unsound (large pipes). The average length of logs 24′, the girth 6′ 6″. There is no abundant supply of good trees, though they grow in clumps. I have seen the logs sold for W. Mahogany when barked. On one occasion a hauler had the audacity to dispose of a log as Blackbutt, which was converted and sold on the Sydney market as such." (A. H. Lawrence, Forest Guard.)

It is generally classed in the Renantheræ, but I would point out that it may be more fittingly termed *renantheroid* and that its anthers are more closely allied to those of *E. diversicolor*, F.v.M.

(*g*) *E. virgata*, Sieb., var. *fraxinoides*, Maiden, *E. fraxinoides*, Deane and Maiden. (White Ash.)

See p. 278, Part ix of my "Crit. Rev." It is there recorded from Tantawanglo Mountain near Cathcart (County Wellesley). It is desirable that additional localities should be recorded for this (at present) rare form, and I, therefore, record it from Ph. Colombo, Co. Auckland, (Assistant Forester Harrison and Dist. Forester Clulee); 20 miles east of Nimitybelle, east of Great Dividing Range, north-east of head of Kybean River (R. H. Cambage. No. 1923.)

(*h*) *E. oleosa*, F.v.M., New for Queensland.

In my "Crit. Rev. Genus Eucalyptus," Part xv, p. 169, I note that this species has been collected in all the States except Tasmania and Queensland. It is a dry country species and has now to be recorded for Queensland, having been found near Jericho by J. L. Boorman. It is a Mallee, and it would appear that Mallee is rare in the Northern State. It grows in masses on red stony ridges around the black soil of the flats, up to 10 feet high as seen. Gidgee (*Acacia Cambagei*, R. T. Baker) and *Gastrolobium grandiflorum*, F.v.M. grow in the immediate neighbourhood.

THE OCCURRENCE OF TRIMETHYLAMINE AND ITS ORIGIN IN THE AUSTRALIAN SALT BUSH, *Rhagodia hastata* R. Br.

By R. W. CHALLINOR, F.I.C., F.C.S.

[*Read before the Royal Society of N. S. Wales, December 3, 1913.*]

Rhagodia hastata is a native of Australia, belonging to the Family Chenopodiaceæ. It is known vernacularly as "Salt-bush," and is one of an extensive collection of plants of this name, indigenous in Australia.

This species is cultivated extensively in the suburban gardens around Sydney, chiefly as an ornamental hedge, and is noted for the peculiar and objectional herring-brine odour which it gives off at certain times of the year when crushed between the fingers. This odour is more particularly noticeable during the spring and summer months, and is often more pronounced in moist weather.

It seemed probable that the fishy odour was due to small quantities of trimethylamine, but as the presence of this substance in the Australian salt bushes had not previously been recorded, this investigation was undertaken with the object of endeavouring to locate it, and incidentally to ascertain the source from which it was derived in the plant.

Chenopodia vulvaria, a European species, has been shown by Von Dessaignes[1] to yield trimethylamine when distilled with alkalis. Hétet[2] also obtained trimethylamine from the fresh plant *Cotyledon umbilicus*. Brieger[3] has shown trimethylamine to be present in ergot as a decomposition product of choline.

[1] Compt. Rend., 43, 670, 1856. [2] Compt. Rend., 59, 29, 1865.
[3] Zeits. Physiol. Chem., II, S. 184, 1887.

Trimethylamine has also been found in *Arnica montana*, the seeds of *Mercurialis annua*, the flowers of *Cratœgus oxyacantha* and *Pyrus aucuparia*, the blossoms of the pear, hawthorn and wild cherry, and in many other plants.

Choline, betaine and allied bases containing a trimethylamine complex appear to be normal constituents in all the Chenopodiaceæ examined according to Schulze and Trier,[1] and Stanék.[2]

As shown in the experimental evidence, trimethylamine was found in the distillate after distilling the salt bush with caustic alkali. It is possible that the whole of this compound thus obtained may have been derived from lecithin or bases like choline, betaine, etc., but that a small quantity also exists naturally in the free state in the growing plant at certain times of the year is shown by the very characteristic herring-brine odour which it emits. Kauffmann and Vorländer[3] have estimated that it is possible to detect ·0000005 gram of trimethylamine by its odour. Further evidence was obtained by distilling some of the fresh plant with water alone, when an alkaline distillate of a pronounced fishy odour was obtained. It was also observed that litmus paper suspended over the freshly cut plant in a closed vessel gradually becomes blue. This small amount of free trimethylamine is probably the result of the decomposition of a more complex substance in the plant by means of an enzyme. The experimental results show that a basic substance containing the trimethylamine complex and closely resembling choline in its chemical properties is the parent substance from which this trimethylamine originates.

---

[1] Journ. Chem. Soc. A., 1912, II, 1203.

[2] Chemical Abstract, 1910, IV, 1181.

[3] Ber. Deut. Chem. Gessells., 43, 2736.

Experimental.

2900 grams of the freshly cut terminal branchlets of the plant were submitted to distillation with caustic alkali, the distillate being received in 5 times normal sulphuric acid, the acid being added from a burette as it became neutralised. 90 cc. of acid was required to neutralise the basic substances in the distillate, which calculated as ammonia = 0·26 per cent. A small amount of an oily substance passed over at the same time, and the distillate whilst acid was pink, the pink colour disappearing again on neutralisation.

The sulphates obtained, after evaporating to dryness, were then extracted with absolute alcohol, the extract when dried over sulphuric acid gave 0·6520 gram of amine sulphates, which calculated to trimethylamine = 0·012 per cent. The dried sulphates were again distilled with caustic alkali and the process repeated, the amounts obtained being identical with those mentioned above.

The amine sulphate was crystalline, deliquescent, and possessed of a strong herring brine odour. On heating with caustic soda it gave off a strong ammoniacal fishy odour and an inflammable vapour, it also gave a precipitate with potassium ferrocyanide from a hydrochloric acid solution, thus showing the presence of a tertiary amine.

A fresh quantity of the green plant was triturated with water acidulated with hydrochloric acid, the filtered extract after concentration was made alkaline with soda and steam distilled into standard acid, the excess of acid titrated with alkali indicated 0·067 per cent. of volatile alkalis calculated as ammonia. The neutralised distillate after evaporating to dryness and extracting with absolute alcohol, gave a crystalline deliquescent substance possessing the properties of trimethylamine. On comparing the results of these two determinations it is evident that a considerable proportion

of the volatile basic substances, obtained by the direct distillation of the plant with caustic soda, must have been derived from some of the nitrogenous constituents which are not readily dissolved in acid water.

The plant on air drying loses 76·5 per cent. of its weight. The dry material was ground fine enough to pass through an 80 mesh sieve, and 20 grams of the powder extracted successively with petroleum ether (boiling below 40° C.), anhydrous ether and absolute alcohol. The proportions dissolved by these solvents, calculated upon the fresh plant were as follows:—

Petroleum ether	0·19	per cent.
Ether	0·16	,,
Alcohol... ...	1·35	,,
Total ...	1·60	

The petroleum ether extract gave evidence of a volatile oil and the ether extract showed the presence of a fatty substance.

The alcoholic extract, after drying and incinerating a portion, showed the presence of 7·97 per cent. of inorganic matter which consisted principally of the chlorides and carbonates of sodium and potassium. 5·9 per cent. of this alcoholic extract was soluble in water (equivalent to 0·07 per cent. on the fresh plant). The water soluble portion was divided and examined as follows:—Basic lead acetate added to a portion gave a yellow precipitate, which after washing was suspended in water, decomposed by means of hydrogen sulphide and filtered; the filtrate after concentrating and boiling for some time with dilute sulphuric acid gave a yellow precipitate which reacted like quercetin with the usual reagents, whilst the filtrate reduced Fehling's solution, thus indicating the presence of a glucoside of quercetin.

Another portion on distillation with caustic alkali, gave a distillate which, when neutralised with hydrochloric acid and evaporated to dryness, gave a deliquescent residue which was completely soluble in absolute alcohol, had the odour of herring brine, and gave the reactions of trimethylamine as before. As the dry residue was dissolved completely by absolute alcohol the absence of ammonium salts was shown. The residue remaining in the flask after this distillation was acidified with sulphuric acid and again distilled, an acid distillate was obtained, which gave all the reactions of acetic acid. That acetic acid is present in the plant, was proved directly, by distilling the fresh branchlets with two per cent. phosphoric acid and converting the acid distillate into the barium salt. 0·2068 gram of the barium salt gave 0·1894 gram of barium sulphate, which indicates a molecular weight of 59·7 for the acid, almost that of acetic acid. This barium salt moreover gave all the characteristic reactions of acetic acid.

The greater part of the trimethylamine obtained in the foregoing experiments appears to have been due to the action of caustic alkalis. Basic substances which would yield this compound when thus treated were then sought for directly by a method similar to that of Schulze.[1] Schulze and Trier[2] consider that choline is not liberated from lecithin during the necessary manipulation of the extracts in separating it from the plant.

About $2\frac{1}{4}$ kilograms of the fresh terminal branchlets, cut in July, when the odour of trimethylamine is not usually discernible in the plant cultivated about Sydney, was passed through a mincing machine and converted into pulp, this was extracted with water several times and separated from solid material by squeezing through cloth. Aqueous lead acetate solution was added, allowed to settle, and the

[1] Zeits. Physiol. Chemie, 60, 155, 1909. [2] *Loc. cit.*, 81, 53, 58, 1912.

clear supernatant liquid siphoned off from the precipitate, the residue being washed twice with water. On removing the excess of lead from the filtrate by means of hydrogen sulphide a considerable amount of sulphur separated out on standing, this being probably due to the action of the nitrates in the plant upon the hydrogen sulphide. A quantity of potassium nitrate also crystallised out when the lead free filtrate was evaporated to dryness. The dry residue was then extracted with alcohol and the clear alcoholic solution treated with an alcoholic solution of mercuric chloride and allowed to stand four days, the clear supernatant liquid was siphoned off and the precipitated double salt of the bases washed five or six times with alcohol and warmed with E strength hydrochloric acid till no more would dissolve. A brown insoluble residue was filtered off and the filtrate evaporated, under diminished pressure, to dryness. This dry residue was again extracted with absolute alcohol, the filtrate again evaporated as before, and the process repeated till no more potassium chloride could be thus separated. The last alcoholic solution on diluting with water gave a dark precipitate which became crystalline on standing, this was filtered off, washed and put by for subsequent examination.

Mercury was removed from the aqueous filtrate by means of hydrogen sulphide and the mercury free filtrate evaporated under diminished pressure, the dry residue extracted with absolute alcohol, filtered, and the process repeated till only a small amount of potassium could be detected in the dry residue. The alcoholic solution of this residue was precipitated with alcoholic platinum chloride and the buff-coloured precipitate filtered and washed with alcohol till free from excess of platinum chloride and dried. On crystallising this double platinum salt from water over sulphuric acid in a vacuum desiccator orange-red dodecahedrons and hexagonal plates separated out.

This platinum salt was then dissolved in water, saturated with hydrogen sulphide and allowed to stand in a warm place for some time to completely precipitate the platinum; the filtrate was evaporated to dryness and the residue repeatedly extracted with absolute alcohol, a small insoluble residue being left which contained traces of potassium.

The alcoholic solution of this residue was evaporated over sulphuric acid in a vacuum desiccator, a crystalline residue being left in the dish, the lower portion consisting of clear colourless monoclinic prisms, which were non-deliquescent, and the upper portion consisting of a crystalline mass which rapidly deliquesced on exposure to the air. Successive washings with small quantities of absolute alcohol readily dissolved the deliquescent portion and left the monoclinic crystals which were found to be much less soluble in this solvent.

An attempt to determine the melting point of this crystalline hydrochloride of the base, showed that at 180°C. it began to change in appearance, and at about 220° C. decomposed giving off a strong odour of trimethylamine and a crystalline sublimate consisting of microscopic fern-like crystals which after some time deliquesced. This crystalline salt also reacts strongly acid to litmus.

A portion dissolved in alcohol and precipitated with alcoholic platinum chloride gave a mass of golden yellow needle crystals of the double platinum salt. These were washed with alcohol, dissolved in water and evaporated to dryness over sulphuric acid under diminished pressure till no further loss in weight occurred. The crystals thus obtained consisted of orange coloured plates and prisms and were anhydrous, as no change in weight occurred after heating them for some time to 115° C. The melting point was somewhat sharp at 217—218° C. (uncorr.) with decomposition. (Henry in "The Plant Alkaloids," p. 328, gives

the melting point of choline platinichloride as 215–240° C. with decomposition).

The amount of platinum in this double salt was 30·68 per cent., theory requires for the platinum salt of choline 31·65 per cent,

The chemical reactions of the crystalline hydrochloride of this base, when tested in comparison with a sample of choline hydrochloride obtained from Burroughs Wellcome and Co., showed remarkable similarity in all directions. The characteristic hygroscopic property of the choline salt however was not observed with the salt of this base, and moreover it was also much less soluble in absolute alcohol. That the isolated base contains the trimethylamine complex is shown by the evolution of this substance when the salt is decomposed by heat, and it appears to be therefore, the source of trimethylamine in *Rhagodia hastata.*

It is hoped that by working on large amounts of this salt bush, sufficient of the base may be isolated to enable the determination of its constitution to be undertaken and also to observe any characteristic physical properties it may have.

In conclusion, I wish to express my thanks to Mr. H. G. Smith, for the unreserved use of the laboratory and library at the Technological Museum in which a considerable amount of this work was done; also to Mr. R. T. Baker for botanical assistance, and to Dr. J. M. Petrie for many references to the literature on choline and similar bases.

NOTE ON AN OSTRACOD, AND AN OSTRACODAL LIMESTONE FROM THE MIDDLE DEVONIAN OF NEW SOUTH WALES.

By Frederick Chapman, A.L.S., F.R.M.S.,
Palæontologist to the National Museum, Melbourne.

(Communicated by W. S. Dun.)

With Plate IX.

[*Received December 16th, 1913.*]

Introduction.

There is no doubt that with careful search the group of the Ostracoda will be found to be well represented in the Devonian rocks of Australia. Up to the present there appears to be only one authenticated example recorded from that system, viz., *Primitia cuneus*, Chapman,[1] from the Middle Devonian of Buchan. Thin slices of limestone of Middle Devonian age from various localities which I have examined from time to time have shown traces of those organisms. It follows, therefore, that our scanty knowledge of the group from strata of Devonian age is due to want of careful search after these minute fossils, especially amongst disintegrated limestone.

The isolated specimen now to be described, was presented to the National Museum collection by Mr. A. J. Shearsby, F.R.M.S., who collected it at Taemas, near Yass. It belongs to the genus *Primitia*, which has a wide range, from the Silurian to the Carboniferous in other parts of the World.

The second record, of a patch of ostracodal limestone found within an *Orthoceras* shell, also from the Yass district, is extremely interesting, showing as it does, that

[1] Rec. Geol. Surv. Vict., Vol. III, pt. 2, 1912, p. 221, pl. xxxvi, f. 10–12.

several other genera besides *Primitia* are probably present in the Middle Devonian Limestone of Australia.

Description.

PRIMITIA YASSENSIS, sp. nov., Plate IX, figs. 1—3.

Seen from the side the carapace is elongate-ovate, narrowing anteriorly; dorsal margin nearly straight; ventral margin gently convex, slightly sinuous in the middle; anterior extremity truncately rounded, posterior extremity obliquely rounded at the ventral angle, and with the dorsal angle truncated. The narrow anterior extremity depressed over one-third the length of the valve, and markedly so towards the antero-ventral angle. Surface tumid in the posterior half, with a moderately deep and curved sulcus, extending from the dorsum to two-thirds across the valve and directed slightly backwards. Surface finely reticulate in places, especially near the margins, the structure being best seen on moistening the specimen. Edge view of valve showing the carapace to be pear-shaped in section.

Measurements.—Length of specimen (left valve) 1·6 mm. Greatest width, 1·08 mm. Depth of valve, ·38 mm.

Affinities.—The present species clearly belongs to the group of which *Primitia mundula*, Rupert Jones, forms the central type, and which ranges from the Upper Silurian to the Lower Devonian.

The nearest allied form to the Australian species is *Primitia scaphoides*, Rupt. Jones,[1] a fossil ostracod from the Lower Devonian of Campbellton, New Brunswick. The sulcus in *P. yassensis*, however, is not so deeply excavated, and there is no sub-acute ridge bordering the side nearer the anterior extremity.

Occurrence.—Middle Devonian, from the 'Cavan cutting' on the left branch of the Murrumbidgee River, Portion 65,

---

[1] Ann. Mag. Nat. Hist., Ser. 6, Vol. III, 1889, p. 337, pl. xvi, fig. 3.

Parish of Taemas, Co. of Cowley. In beds containing *Chonetes culleni*, Dun. Presented by Mr. A. J. Shearsby, F.R.M.S.

Note on Ostracodal Limestone from the Middle Devonian of Cavan, Yass.

Accompanying the foregoing specimen of *Primitia* there is a microscopic slide prepared by Mr. Shearsby, of a fragment of an *Orthoceras* shell from the Devonian Limestone of Cavan. This thin slice is seen to be crowded with the separate valves and carapaces of at least three species and probably two genera of Ostracoda. The commonest forms are clearly referable to *Primitia*, whilst occasionally there is a rather peculiarly shaped form with a long spinous process, reminding one of *Æchmina*. The affinities of this latter type are at present conjectural, as there are no very definite or complete outlines of the carapace in the slice examined. Of the *Primitiæ*, one form, the more common, is moderately short-ovoid, and resembling generally the *P. cuneus* before mentioned, of the Middle Devonian of Buchan, Victoria. The other species is long-ovate, anteriorly acuminate in edge view, with an antero-median sulcus.

The general characters of the limestone are, a subcrystalline rock, very compact, crowded with ostracodal remains. The matrix or cement is a moderately fine calcitic mud, almost entirely re-crystallised, and completely filling up all the interspaces between the organic remains. Besides the ostracoda there are small ossicles of crinoidal origin. The ostracodal valves show the original typical microfibrous structure and characteristic dark brown colour as compared with the pelecypod shells; whilst in many of the interiors of the still perfect carapaces, remains of the original animal-organism are seen in the patches of carbon particles still enclosed within the valves.

To give some idea of the great abundance of these little organisms that have drifted into the empty chamber of an *Orthoceras* shell, I counted over an average portion of the slide, which gave the result of 20,000 individuals in 1 cubic centimetre.

Occurrence.—In an infilling of an *Orthoceras* shell from the Parish of Taemas, New South Wales.

Explanation of Plate.

Fig. 1. *Primitia yassensis*, sp. nov. The specimen, a left valve, seen from the side. Middle Devonian, Taemas, near Yass. × 26.

Fig. 2. *P. yassensis*, sp. nov. Outline of valve, edge view. × 26.

Fig. 3. *P. yassensis*, sp. nov. Ornament of valve, somewhat restored, seen near the ventral margin. × 52.

Fig. 4. Photomicrograph of an ostracodal limestone with *Primitiæ* etc., from Taemas, near Yass

CONTENTS.

ISSUED MARCH 19th, 1914.

Vol. XLVII. **Part III.**

JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1913.

PART III, (pp. (i)–(xxii), i–l.)

Containing Abstract of Proceedings, Title Page, List of Publications, Contents, List of Members, etc., and Index.

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH, SYDNEY.
LONDON AGENTS:
GEORGE ROBERTSON & Co., PROPRIETARY LIMITED,
17 WARWICK SQUARE, PATERNOSTER ROW, LONDON, E.C.

1913.

F. WHITE Typ. 344 Kent Street Sydney.

ABSTRACT OF PROCEEDINGS

Q—December 3, 1913.

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

ABSTRACT OF PROCEEDINGS, MAY 7th, 1913.

The Annual Meeting, being the three hundred and fifty-sixth (356th) General Monthly Meeting of the Society, was held at the Society's House, 5 Elizabeth-street North, at 8 p.m.

Mr. R. H. CAMBAGE, President, in the Chair.

Forty-eight members and one visitor were present.

The minutes of the General Monthly Meeting of the 4th December, 1912, were read and confirmed.

The certificates of eleven candidates for admission as ordinary members were read for the first time.

The receipt, during the recess, of 414 parts, 15 volumes, 26 reports, 5 catalogues and 3 maps was reported.

A letter was read from the Private Secretary to H.E. the Governor of New South Wales, stating that His Excellency had accepted the office of Vice-Patron of the Society.

A circular letter was read announcing the formation of the Lister Memorial Fund Committee, and requesting that subscriptions towards a memorial in honour of the late Lord LISTER should be sent to the Committee, care of the Royal Society, London.

A report on the state of the Society's property and the following annual report of the Council were read.

Annual Report of the Council for the Year 1912–13
(1st May to 30th April.)

1. Eight ordinary General Meetings and one adjourned ordinary meeting were held.

2. Twelve meetings of the Council were held.

3. Twelve papers were read at the ordinary General Meetings.

4. At the September meeting a discussion took place on "Popularising Forestry in New South Wales." Members of certain public bodies interested in the subject were present by invitation and took part in the proceedings.

5. Four Popular Science Lectures were given during the year, the titles being as follows:—

July 18—"*Shifts for a Living in the Plant World*," by G. P. Darnell-Smith, B.Sc., F.I.C.

August 15—"*The Wonders of the Soil*," by Professor Watt, M.A., B.Sc.

September 19—"*Pre-Historic Man*," by S. A. Smith, M.B., Ch.M.

October 17—"*Drought-resisting Plants*," by A. G. Hamilton.

They were all excellently attended and members and the public are under great obligation to the lecturers for their admirable discourses.

6. On the 14th April an informal meeting of members took place to wish God-speed to Mr. Frank Wild, leader of Dr. Mawson's Western Party, who was proceeding to England, and to welcome other members of the Expedition who had arrived in Sydney.

7. Fourteen gentlemen have been elected members of the Society during the year.

8. Ten members were lost to the Society by death or resignation.

9. One Honorary Member, Dr. C. J. Martin, F.R.S., Director of the Lister Institute for Preventive Medicine,

and one Corresponding Member, Dr. T. HARVEY JOHNSTON of the University of Queensland, were elected.

10. Miss ALICE MAUD DUNN was appointed clerk on 23rd May, 1912, and continues in office.

11. Delegates were appointed to:—

a. The 250th Anniversary of the Royal Society of London (Mr. CHARLES HEDLEY).

b. The Bi-centenary of the Medical School of Trinity College, Dublin (Prof. LIVERSIDGE).

c. Eighth International Congress of Applied Chemistry, Washington and New York (Prof. WARREN).

d. Melbourne Meeting of the Australasian Association for the Advancement of Science—(Mr. R. H. CAMBAGE, President, Mr. H. G. SMITH, and Dr. J. B. CLELAND).

e. New South Wales Local Committee for the visit of the British Association in 1914—Mr. R. H. CAMBAGE, Mr. W. M. HAMLET, and Dr. J. B. CLELAND).

f. Ceremonies of inauguration dedication, Rice Institute, Houston, Texas, U.S.A., 10–12th October, 1912 (Prof. WARREN).

12. The Annual Dinner of the Society took place on 24th April, at Farmer's Rooms, 87 persons taking part in the function. The guests comprised the Chief Justice (Sir WILLIAM CULLEN), Sir ALFRED BATEMAN, a member of the Dominions Royal Commission, and several members of the Scott and Mawson Expeditions who had recently returned from Antarctica.

The Financial Statement for the year ended 31st March, 1913, was submitted to members, and, on the motion of the Honorary Treasurer, Mr. D. CARMENT, it was unanimously adopted:—

GENERAL ACCOUNT.

Dr. Receipts.				£	s.	d.	£	s.	d.
To Cash in Hand 1st April, 1912				20	19	0			
,, Balance in Bank on 1st April, 1912				99	10	7			
							120	9	7
,, Subscriptions				545	16	0			
,, Parliamentary Grant on Subscriptions received 1912-1913				400	0	0			
,, Rents—									
Offices	244	5	0						
Hall and Library	193	13	6						
				437	18	6			
,, Sundry Receipts...				13	15	2			
							1397	9	8
,, Clarke Memorial Fund—Amount advanced to Building and Investment Fund towards reduction of Mortgage							300	0	0
							£1817	19	3

Payments.	£	s.	d.	Cr. £	s.	d.
By Salaries and Wages—						
Office Salaries and Accountancy Fees ...	157	15	1			
Assistant Librarian...	107	10	0			
Caretaker	130	7	6			
				395	12	7
,, Printing, Stationery, Advertising, Stamps etc.						
Advertising	14	3	0			
Office Sundries	9	7	8			
Stamps and Telegrams	25	15	3			
Stationery	19	12	8			
				68	18	7
,, Rates, Taxes and Services—						
Electric Light	20	4	6			
Gas	5	7	8			
Insurance	20	0	5			
Rates	75	5	0			
Telephone	7	14	6			
				128	12	1
,, Printing and Publishing Society's Volume—						
Printing	342	9	6			
Blocks	39	13	8			
Freight, Charges and Packing	39	14	2			
				421	17	4
,, Library—						
Books and Periodicals	124	2	10			
Bookbinding...	14	4	10			
				138	7	8
Carried forward				1153	8	3

Payments—*continued*.	£ s. d.	£ s. d.
Brought forward		1153 8 3
By Sundry Expenses—		
Bank Charges and Exchange	0 12 0	
Repairs	4 4 2	
Lantern Operator	9 0 0	
Sundries	40 9 2	
		54 5 4
„ Interest on Mortgage	119 10 0	
Clarke Memorial Fund	3 9 6	
		122 19 6
„ Special Fee, Accountant's Investigation ...		42 0 0
„ Plant, Fixtures and Fittings...		32 10 6
„ Dinners, Deficiency on Dinner Tickets ...		35 12 0
„ A.A.A. Science on a/c Repayment of Loan		300 0 0
„ Balance at Credit Union Bank of Australia		77 3 8
		£1817 19 3

BUILDING AND INVESTMENT FUND.

Dr.	£ s. d.
To Loan on Mortgage at 4% at 31st March, 1912	3100 0 0
	£3100 0 0

Cr.	£ s. d.	£ s. d.
By Deposit in Government Savings Bank,		
March 31st, 1912	1 8 2	
Interest to date	0 2 2	
		1 10 4
„ Amount paid A.A.A. Science on a/c of Loan		300 0 0
„ Balance at this date		2798 9 8
		£3100 0 0

CLARKE MEMORIAL FUND.

Dr.	£ s. d.
To Amount of Fund, 31st March, 1912	532 11 11
„ Interest to 31st March, 1913, Savings Bank	15 8 11
„ „ „ General Fund	3 9 6
„ General Fund, refunds to date	239 0 0
	£790 10 4

Cr.	£ s. d.
By Advances to General Fund	239 0 0
„ Advance to Building and Investment Fund towards reduction of Mortgage	300 0 0
Carried forward	539 0 0

	£ s. d.	£ s. d.
Brought forward		539 0 0
By Balance—		
Deposited in Savings Bank of N. S. W., March 31, 1913	211 2 11	
Deposited in Government Savings Bank	40 7 5	
		251 10 4
		£790 10 4

Compiled from the books and accounts of the Royal Society of New South Wales and certified to be in accordance therewith.

D. CARMENT, *Honorary Treasurer.*

W. PERCIVAL MINELL, *Public Accountant and Auditor.*

SYDNEY, 25TH APRIL, 1913.

The President then delivered the Annual Address.

It was proposed by Mr. E. C. ANDREWS, seconded by Mr. R. T. BAKER, and supported by Mr. J. H. MAIDEN, and Mr. J. E. CARNE, that the hearty thanks of members be given to Mr. CAMBAGE for his admirable address.

Mr. CAMBAGE briefly acknowledged the compliment.

There being no other nominations, the President declared the following gentlemen to be Officers and Council for the coming year:—

President:

HENRY G. SMITH, F.C.S.

Vice-Presidents:

F. H. QUAIFE, M.A., M.D. | D. CARMENT, F.I.A., F.F.A.

F. B. GUTHRIE, F.I.C., F.C.S. | R. H. CAMBAGE, L.S., F.L.S.

Hon. Treasurer:

H. G. CHAPMAN, M.D.

Hon. Secretaries:

J. H. MAIDEN, F.L.S. | Prof. POLLOCK, D.SC.

Members of Council:

J. B. CLELAND, M.D., CH.M.

Prof. T. W. E. DAVID, C.M.G., B.A., D.SC., F.R.S.

W. S. DUN.

R. GREIG-SMITH, D.SC.

W. M. HAMLET, F.I.C., F.C.S.

C. HEDLEY, F.L.S.

T. H. HOUGHTON, M. INST. C.E.

C. A. SUSSMILCH, F.G.S.

H. D. WALSH, B.A.I., M. INST. C.E.

Prof. W. H. WARREN, LL.D.

Mr. CAMBAGE, the outgoing President, then installed Mr. SMITH as President for the ensuing year, and the latter briefly returned thanks.

ABSTRACT OF PROCEEDINGS, JUNE 4th, 1913.

The three hundred and fifty-seventh (357th) General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth-street North, on Wednesday, June 4th, 1913, at 8 p.m.

Mr. H. G. Smith, President, in the Chair.

Thirty-five members and four visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of candidates for admission as ordinary members were read: eleven for the second, and five for the first time.

The following gentlemen were duly elected as ordinary members of the Society:—

J. H. C. Stuart, 56 Pitt Street.

W. M. Doherty, Department of Public Health, Sydney.

J. Thompson, m.a., ll.b., Vickery's Chambers, 82 Pitt Street.

A. H. Stewart, b.e., Technical College, Sydney.

S. Dodd, d.v.s., f.r.c.v.s., The University, Sydney.

H. S. H. Wardlaw, b.Sc., 87 Macpherson Street, Waverley.

J. E. Bishop, Killarney Street, Mosman.

R. E. Ullrich, 43 Bond Street, Mosman.

Prof. R. Robinson, d.Sc., The University, Sydney.

Prof. A. A. Lawson, d.Sc., The University, Sydney.

W. R. Browne, b.Sc., The University, Sydney.

The President made the following announcements:—

1. That a letter had been received inviting the President and members to be present at the opening of the new buildings of the Australian Institute of Tropical Medicine at Townsville on the 28th June.

2. That Mr. E. C. ANDREWS would address the Geology Section at its meeting of the 11th instant on the Geology of Cobar.

3. That the donations received during the month were 19 volumes, 257 parts, 31 reports.

Letters were read from Mr. TEBBUTT, Rev. W. SCOTT, and Col. J. H. GOODLET, thanking members for their kind messages of congratulation.

It was resolved that the congratulations of the Society be offered to the Western Australian Astronomical Society on its inauguration.

It was resolved to send His Honour Judge DOCKER a message of sympathy in regard to his recent accident, and good wishes for his speedy recovery.

THE FOLLOWING PAPERS WERE READ:

1. "Products of the action of concentrated sulphuric acid on Iron," by CHARLES W. R. POWELL, Science Research Scholar, The University of Sydney. (Communicated by Prof. FAWSITT, D.Sc.)

2. Notes by Dr. J. B. CLELAND:—Occurrence of Coccidiosis in House Sparrows and in Bovines in New South Wales; on the Growth of Flowering Stem of *Xanthorrhœa hastilis*, R. Br.; on Agar-agar Seaweed from Western Australia.

Dr. CHAPMAN communicated some notes on the freezing points of blood sera and corpuscles of the ox, sheep, pig and man. The blood corpuscles were laked by freezing and thawing the corpuscles separated by spinning in a centrifuge. It was found that the freezing point of the corpuscles was less than the freezing point of the corresponding serum. When the corpuscles were washed with 0·9% Na Cl, the freezing point of the washed corpuscles was higher than the freezing point of the unwashed corpuscles. If the

corpuscles were washed three times with 0·9% Na Cl, the freezing point of the corpuscles was higher after each washing. When the corpuscles were washed with Ringer's solution the freezing point of the corpuscles remains unchanged after each of three separate washings.

Remarks were made by Mr. DARNELL-SMITH, Dr. GREIG-SMITH, and the President.

EXHIBITS:

1. Restorations of Merostomatous Crustacea from America, by W. S. DUN.

2. Pine needles and materials made from them, by R. T. BAKER, F.L.S.

3. Specimens illustrating frost and spray injuries to plants: apple-canker and coconut-bud rot, by EWEN MACKINNON, B.Sc.

ABSTRACT OF PROCEEDINGS, JULY 2nd, 1913.

The three hundred and fifty-eight (358th) General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth-street North, at 8 p.m.

Mr. H. G. SMITH, President, in the Chair.

Forty members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of candidates for admission as ordinary members were read: five for the second, and one for the first time.

Mr. R. T. BAKER and Mr. W. WELCH were appointed Scrutineers, and Mr. C. HEDLEY deputed to preside at the Ballot Box.

The following gentlemen were duly elected as ordinary members of the Society:—

Prof. W. E. COOKE, M.A., F.R.A.S., The Observatory.

F. A. COOMBS, F.C.S., 55 Willoughby Road, Crow's Nest, North Sydney.

G. I. HUDSON, "Gudvangen," Arden St., Coogee, Sydney.

The Rev. T. ROSEBY, M.A., LL.D., F.R.A.S., "Tintern," Mosman.

W. H. TIETKENS, "Upna," Eastwood.

The President made the following announcements:—

1. That a Popular Science Lecture entitled "The Grand Cañon of Colorado and its Lessons," by E. C. ANDREWS, B.A., would be delivered in the Society's Hall, on July 17th, 1913.

2. That Dr. QUAIFE had generously presented £20 towards the expenses of the library.

3. That donations consisting of 4 volumes, 174 parts, 19 reports and 3 maps were laid upon the table.

A letter of thanks from His Honour Judge DOCKER in acknowledgment of the Society's letter of sympathy in his recent accident was read.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on Eucalyptus, (with descriptions of new species) No. I," by J. H. MAIDEN.

E. tesselaris, F.v.M. var. *Dallachiana*, Benth. is shown to be a variety of *E. clavigera*, A. Cunn., and the imperfectly known species *E. leptophleba*, F.v.M. a Box, and *E. drepanophylla* an Ironbark, are clearly defined.

Four species are described as new. (1) A tree from Concord, near Sydney, which possesses characters intermediate between the Grey Ironbark (*E. paniculata*) and the Grey Box (*E. hemiphloia*). (2) A Mallee-like tall shrub or small tree from Ticketty Well, near Wallangra, which goes under the name of "Mallee-Box," a remarkable nar-

row-leaved species, having buds with long opercula of less diameter than the calyx-tube, and small fruits with well-exserted awl-like tips. (3) One of the Yellow Jackets from the desert country west of Emerald, whose closest affinity is *E. Baileyana.* (4) A Blackbutt of Central Queensland, a large tree with scaly bark at the butt, which is sharply defined from the smooth white stem. The timber is deep red and it has affinity to the Red Box (*E. polyanthemos*) of New South Wales.

2. "Note on the Paraffins of Eucalyptus Oils," by H. G. SMITH.

Dr. J. B. CLELAND referred to a curious light, like the mast head light of a steamer, that he had seen in February, 1909, at the entrance to St. Vincent's Gulf in South Australia. He was on deck just as dusk came on and, whilst daylight lasted, all was clear ahead. Just as dark was settling down, he saw, quite close to the port side of the ship and suspended in the air, a light like the mast-head light of a ship, which soon disappeared. No ship could be discovered, and, as previously stated, none was in sight a few minutes previously. A seaman who passed and was questioned, had not noticed it. This incident had not been considered of much importance—in fact was supposed to be an error of observation—until, some while afterwards, the following cutting appeared in a Sydney paper, describing *the same phenomenon from the same place.* The date has, unfortunately, not been kept. The account, which is from Adelaide, is as follows:—

"Captain Nelsson, of the coastal steamer "Wookata," the second engineer, Mr. S. Arnold, and helmsman, Mr. G. Rudd, are at a complete loss to explain the meaning of curious lights which they witnessed when the vessel was passing Althorpe Island on the way to Port Adelaide early the other morning. 'Bright lights as distinct as masthead lights of a steamer, but high up in the air,'

were observed by the trio, and a strange thing was that they circled around the "Wookata" in a tantalising way. 'It was about 3 o'clock,' says Captain Nelsson, 'that the man at the wheel remarked, Do you see these lights flying about?' I replied, 'Yes, there are a great many more lights about than I have ever seen here.' Just then I saw a mysterious light off Cape Spencer, which disappeared as suddenly as it came into view. Presently the helmsman said, 'It is strange, but I have seen lights on the port bow, then right ahead, then on the starboard side.' I stepped inside the wheelhouse, and on coming out again saw two lights just over the starboard bow, no distance away, but high up. They seemed to pass us. They were as bright as our masthead lights, and as far as I could judge, were 200 or 300 yards distant. The lights appeared to be 10 yards apart, one a little above the other. I could not make it out. I said to the man at the wheel, 'Did you see them?' He answered, 'Yes, they are like German airships flying about.' I did not know what to think. I feel sure I saw something unusual—something which in my 45 years' experience at sea I had never observed before.' The second engineer also declares he saw the strange lights."

The phenomenon was perhaps a natural one and not due to human agency, and these two incidents are therefore recorded, for what they are worth before this Society, so as to attract scientific attention should they be manifested again.

EXHIBITS :

Dr. J. B. CLELAND exhibited, on behalf of Mr. EDWIN CHEEL and himself, the following Australian Fungi:—

Stropharia stercoraria.—The record is new for Australia. This Agaric is closely allied to *S. semiglobata*, the chief naked-eye differences being given by Massee as a distinct cord-like pith in the stem, a flocculose stem when young and a flat cap at maturity, the latter being persistently semi-globose. The spores of *S. semiglobata* are given by Massee as $12\mu \times 6\mu$, by Cooke as 13 to $14\mu \times 8$ to 9μ.

Massee gives the spores of *S. stercoraria* as 18 to 20μ × 8 to 10μ, and indicates this as being one of the distinguishing features. In our specimens, the stem is hollow, the hollow being sometimes lined by a white pith, and the semi-globose cap expands so as to become almost flat. The spores vary from 16·5 to 20μ × 10μ. Though our specimens are, perhaps, not quite typical of *S. stercoraria*, they certainly do not agree with *S. semiglobata*. We consider ourselves justified, at present at least, in considering them variants of *S. stercoraria*. The fungus is common on dung, being usually considered as *S. semiglobata*. We have specimens from Sydney, Hawkesbury River and Coonamble (J.B.C.)

Craterellus cornucopioides.—New record for New South Wales. Recorded from Queensland. Edible. Found under trees at Neutral Bay, May, 1913 (J.B.C.). Spores pear-shaped, one end pointed, 10 to 11·5μ × 6 to 7μ. Cooke's measurements of the spores are 12 to 14μ × 7 to 8μ.

Craterellus multiplex, Cke. and Massee. New record for New South Wales. Recorded from Tasmania. Centennial Park, Sydney, Sept., 1901 (E.C.) Spores 2 to 3·5μ.

Cortinarius (Myxacium) Archeri, Bern. New record for New South Wales. Recorded from Tasmania. Found at Sydney and Hawkesbury River (J.B.C.). Not rare. The violet tint of the cap disappears with age, leaving only the brown. The base of the stem is sometimes bulbous. Spores 9 to 10μ to usually 11·5 to 13·5μ × 4·5 to 7μ. (Cooke, 11 to 12μ long).

Mr. R. T. Baker exhibited crude oil of *Eucalyptus globulus* from California.

Mr. A. M. McIntosh exhibited a model of a bird's wing to demonstrate equilibrium in flight.

ABSTRACT OF PROCEEDINGS, AUGUST 5th, 1913.

The three hundred and fifty-ninth (359th) General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth-street North, at 8 p.m.

Mr. H. G. SMITH, President, in the Chair.

Forty-seven members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of candidates for admission as ordinary members were read: one for the second, and three for the first time.

His Honour Judge DOCKER and Mr. J. E. CARNE were appointed Scrutineers, and Dr. J. B. CLELAND deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

A. D. OLLE, "Kareema," Charlotte Street, Ashfield.

The President made the following announcements:—

1. That the Popular Science Lecture on "The Evolution of Architectural Style," by Mr. JAMES NANGLE, would be delivered in the Society's Hall, on August 21st, 1913.

2. That donations consisting of 174 parts, 4 volumes, 19 reports and 3 maps were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "The Physiography of Botany Bay," by G. H. HALLIGAN. Remarks were made by Mr. W. M. HAMLET, Mr. E. C. ANDREWS, and Dr. QUAIFE.

2. "The Seedlings of the *Angophoras*, and description of a new species," by Dr. CUTHBERT HALL, communicated by Mr. R. T. BAKER. The paper was, by permission of the President, read by Dr. HALL. Remarks were made by Dr. CHAPMAN and Mr. E. C. ANDREWS.

3. "On the Essential Oils of the *Angophoras*," by H. G. SMITH. Remarks were made by Mr. MAIDEN.

EXHIBITS:

1. Model of Bird-shaped Hydro-aeroplane, by Mr. A. M. MCINTOSH. Remarks were made by Mr. L. HARGRAVE.

2. Model of Southern Coal Field, made by Mr. L. F. HARPER, Geological Surveyor, by Mr. J. E. CARNE with the permission of the Under Secretary for Mines.

The model represents an area of about 3,600 square miles and embraces the whole of the south-eastern portion of the coal bearing basin of New South Wales, containing all the Southern Collieries. The data necessary for the construction was obtained during a Geological Survey of the area by Mr. L. F. HARPER, F.G.S., Geological Surveyor in the State Department of Mines. This work was carried out under the direction of Mr. E. F. PITTMAN, A.R.S.M., Government Geologist, and extended intermittently over a period of about twelve years. A number of maps and geological sections have been reproduced and a memoir is now in course of preparation. An outline of the method of construction is as follows:—The necessary maps were mounted on a wooden base, the horizontal scale adopted being two miles to an inch. Pins were driven in at all necessary spots, over 2,000 being used, and cut off to scale at the levels represented, the vertical scale being 2,000 feet to an inch, an exaggeration of about $5\frac{1}{4}$ times the horizontal scale. Lengths of copper wire were bent to agree with the windings of the principal watercourses, and then mounted in position on stops cut to represent the correct altitude. Plaster of Paris was used to mould the contours roughly and was subsequently carved into the correct form. The area dealt with had been geologically surveyed in detail, so that the data available and personal familiarity with the country resulted in a fairly accurate representa-

tion. Casts of the original were made at the Sydney Technical College, then coloured to depict the various geological formations, and the main roads, rivers and railway lines indicated with sufficient names painted on to enable the geography of the area to be followed. The completed model renders it easy to follow the physical features, including the catchment area of the Sydney Water Supply, and the general geology. It should prove useful for educational purposes and copies have been supplied to the Sydney University and Technical College, as well as to the Military Intelligence Corps, whilst a copy will be exhibited temporarily in the Tourist Bureau Window, Challis House, and permanently at the Mining and Geological Museum, Lower George Street.

3. Photograph of Reptilian Footprints in the Bulli Coal Measures, by W. S. Dun.

4. Delegate Meteorite, by Mr. J. E. Carne.

The specimen weighs 61 ℔s. and looks like a piece of rusty metallic iron, the shape somewhat resembling a thick stumpy boomerang. It was found about six miles N.N.E. of Delegate, and its existence has been known for ten or twelve years. When struck with a stone or hammer it emits a bell-like sound, and amongst the explanations given for the origin were that it had either been a bag of bullock bells smelted together by a bush fire, or a small blacksmith's anvil subjected to the same treatment.

ABSTRACT OF PROCEEDINGS, SEPTEMBER 3rd, 1913.

The three hundred and sixtieth (360th) General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth-street North, at 8 p.m.

Mr. H. G. SMITH, President, in the Chair.

Thirty-three members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three candidates for admission as ordinary members were read for the second time.

Messrs. C. A. SUSSMILCH and R. H. GRIEVE were appointed Scrutineers, and Mr. W. M. HAMLET deputed to preside at the Ballot Box.

The following gentlemen were duly elected as ordinary members of the Society:—

RICHARD WESTMAN CHALLINOR, F.I.C., F.C.S., Technical College.

EDWIN CHEEL, Botanical Assistant, Botanic Gardens, Sydney.

HAROLD ERIC KUNTZEN, Manufacturing Chemist, Australian Glue and Gelatine Works, Alexandria.

The President made the following announcements:—

1. That a Popular Science Lecture, entitled "Alkali, Alkaloid, Alkohol," by Mr. W. M. HAMLET, F.I.C., would be delivered in the Society's Hall, on September 18th, 1913, at 8 p.m.

2. That donations consisting of 3 volumes, 354 parts, 11 reports, and 3 maps, were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on the rectifying property in Silicon and Selenium," by O. W. VONWILLER, B.Sc.

2. "Ionisation caused by penetrating γ rays in a closed thick-walled vessel," by S. E. PIERCE, B.Sc., communicated by Prof. POLLOCK.

Brief Lecturette by J. H. MAIDEN, on those Prickly Pears *(Opuntias)* which interest Australians, illustrated by coloured drawings and fresh specimens.

Remarks were made by Messrs. HAMLET and DARNELL-SMITH, and by the Rev. Dr. ROSEBY.

EXHIBITS:

Marble from near Marulan, by Mr. C. A. SUSSMILCH, F.G.S.

ABSTRACT OF PROCEEDINGS, OCTOBER 1st 1913.

The three hundred and sixty-first (361st) General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth-street North, at 8 p.m.

Mr. H. G. SMITH, President, in the Chair.

Forty-two members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two candidates for admission as ordinary members were read for the first time.

The President made the following announcements:—

1. That a Popular Science Lecture entitled "Irrigation in India and in Egypt," by Prof. W. H. WARREN, LL.D., would be delivered in the Society's Hall, on October 16th, 1913.

2. That donations consisting of 5 volumes, 129 parts, 7 reports and 9 maps, were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "The Extraction of Radium from the Olary Ores," by S. RADCLIFF.

In the year 1906, Mr. W. S. CHAPMAN, Government Assayer of South Australia discovered that the yellow substance encrusting a mineral sample sent in for gold assay was carnotite, a rare uranium mineral which had previously only been found in Colorado, U.S.A. The discovery was considered of such importance that Mr. H. Y. L.

BROWN the Government Geologist, at once visited the locality and reported the existence of a large deposit of radioactive ore. Dr. D. MAWSON afterwards examined the occurrence and published a paper on it. A few years later the Radium Hill Company was formed in Sydney to work the deposit, and 30 tons of ore was sent to Europe in charge of Dr. MAWSON. The European chemists found the ore so difficult to treat that no buyers could be found for it. Mean time the directors of the company commissioned the writer of this paper to investigate the possibility of treating the ore locally, and the process now described is the outcome of his work. The Olary deposit differs from other radium ore occurrences in that it consists of a large well defined lode of low grade ore of very uniform composition. It is characteristic of the rich radium ores that the ore bodies are small and irregular. The essential feature of the process now worked at Woolwich is that it is designed to handle a large tonnage cheaply and simply. The plant is capable of treating 500 tons a year. The process depends on the discovery that it is possible to extract the radium without having to decompose the whole of the ore, thus effecting great economies in chemicals and labour. The concentrates contain 1 part of radium in 214 million parts of ore, and extraction is effected by means of successive concentrations. The radium from 10 tons of concentrates is collected first in one ton of material, then in about 25 lbs. of richer product, and finally worked up to a marketable product in the laboratory.

Remarks were made by Professors POLLOCK and FAWSITT and Mr. HAMLET.

2. "Vanilla and a short and simple method for the determination of Vanillin," by W. M. DOHERTY.

The author described this important and interesting plant, which is now used throughout the civilised world,

having been introduced into Europe as a perfume by Cortes, the celebrated Spaniard. It was known in Queen Elizabeth's time in England as a medicine, and to it was ascribed certain curious physiological properties. Its chief interest to the chemist is the fact that its active ingredient, to which it owes its characteristic odour, namely, vanillin, was one of the first important substances to be synthesised. This vanillin, which was originally sold at £160 per pound, can now be purchased for less than £1, and this great reduction is due to systematic chemical research. The chief point of the paper dealt with the determination of the vanillin, which should be present in a certain proportion in genuine essences, and a simple accurate and expeditious method was shown which can replace the more elaborate one now in use.

Remarks were made by Messrs. HAMLET and MAIDEN.

3. "A flame test for chloral hydrate," by W. M. DOHERTY.
Remarks were made by Mr. HAMLET and Dr. QUAIFE.

4 " On some transverse tests of Australian and Foreign Timbers," by JAMES NANGLE, F.R.A.S.

Remarks were made by Mr. CLUNIES ROSS, Mr. BISHOP, and Mr. HALLIGAN.

EXHIBIT :

Fossil leaves from Torbanelea Colliery, Queensland, by Mr. W. S. DUN.

These specimens give evidence of the occurrence of a species of *Phyllopteris*, smaller in form than *P. Feistmanteli*, which has been recorded from the Styx River coalfield, and Stewarts Creek, near Rockhampton in Queensland, and Kuntha Hill, mouth of Leigh's Creek, South Australia. These horizons have been regarded of Ipswich (Lower Mesozoic) age—Trias-Jura of Queensland Geologists. The specimens are of Marine Cretaceous beds

associated and overlaid by freshwater series apparently of Ipswich age, but hitherto not yielding determinable fossils. This points to the probable contemporaneity of the freshwater (Ipswich) series and the Rolling Downs (Lower Cretaceous) marine sediments.

ABSTRACT OF PROCEEDINGS, NOVEMBER 5th, 1913.

The three hundred and sixty-second (362nd) General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth-street North, at 8 p.m.

Mr. H. G. SMITH, President, in the Chair.

Thirty-three members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of candidates for admission as ordinary members were read: two for the second, and one for the first time.

Dr. R. GREIG-SMITH and Professor C. E. FAWSITT were appointed Scrutineers, and Mr. R. H. CAMBAGE deputed to preside at the Ballot Box.

The following gentlemen were duly elected as ordinary members of the Society:—

L. F. HARPER, F.G.S., Department of Mines, Sydney.

W. J. SCAMMELL, Manufacturing Chemist, 18 Middle Head Road, Mosman.

A letter was read from Mrs. HINDER, thanking the Society for its letter of condolence on the death of her husband.

The President made the following announcement:—

That donations consisting of 5 volumes, 215 parts, 21 reports, 3 calendars and 1 map were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "On the Australian Melaleucas and their Essential Oils," Part V, by R. T. Baker, F.L.S. and H. G. Smith, F.C.S.

The species investigated in this number of the series are *Melaleuca leucadendron*, Linn. and its alleged synonyms. This was the first species described in the genus, and was recorded by Linnæus under the impression that it was from it that the East Indian oil of "Cajuput" was derived from its leaves. This was afterwards shown to be an error, and that it was *M. minor* which yielded the oil. There are several Melaleucas with broad leaves somewhat similar to the *M. leucadendron* growing around the east and north coasts of Australia, and although most of these have at various times been given specific names which have, however been synomyised under Linnæus' species, a comparison of these with the original has shown them to be distinct both botanically and chemically. This paper deals with the systematic history of each species, their geographical distribution, timbers, and chemistry of the oils. The essential oil obtained from two of the species differs considerably from that known as "cajuput," which oil has been supposed in the past to have been derived from a similar tree. The main portion of oil of "cajuput" consists of cineol, a constituent common to very many of the oils of the Melaleucas; the alcohol terpineol has also been isolated from "cajuput." The oil from *Melaleuca Maideni* differs considerably from "cajuput" in that it contains much less cineol, and in the high boiling constituents not being the same. The oil of *Melaleuca Smithii* consists almost entirely of high boiling constituents of which the greater portion is a sesquiterpene alcohol, which, from its physical and other properties, seems to belong to the open chain series. This alcohol, which has been named melaleucol, thus differs from the sesquiterpene alcohols usually found in essential oils,

and this appears to be the first time that such an alcohol has been found occurring in the leaves of any plant. The oil of this species does not appear to contain at any time more than 5 per cent. of cineol, usually less than 2 per cent., and differs almost entirely from "cajuput oil." The oil of this species may eventually be found to be of value in the perfumery industry.

Remarks were made by Mr. CLUNIES ROSS and Dr. J. B. CLELAND.

2. "Some Physico-Chemical measurements on Milk," by H. B. TAYLOR, B.Sc., Science Research Scholar, University of Sydney, (Communicated by Prof. FAWSITT.)

This paper was read by Mr. TAYLOR, by permission of the President, and remarks were made by Prof. FAWSITT and Dr. CHAPMAN.

EXHIBITS:

1. Portraits of Assistant-Surveyor LARMER, by Mr. J. H. MAIDEN.

JAMES LARMER was the son of JAMES and FRANCES LARMER, and was born at Sunning Hill near Ascot, Berks, England, and was baptised at the church of St. Michael and all Angels in his native village on December 16th, 1808. He was probably born, therefore, about the beginning of December in that year. He was 21 years of age when he was appointed by the Imperial Government to come to New South Wales as an Assistant Surveyor under Major MITCHELL, Surveyor General of New South Wales, and at the time of his death he was the last of the so-called Imperial Surveyors. He accompanied Major MITCHELL on his expedition to western New South Wales, and is freely mentioned by him in Volume I of MITCHELL'S "Three Expeditions." He was much esteemed in his profession, and the Lands Department sometime ago transferred to the Mitchell Library his manuscript vocabulary of native names

of places, but it does not appear that he published independently. His last appointment under the Lands Department was at Braidwood as District Surveyor, and when he retired from that office he continued to reside there, where he died on the 5th June, 1886. This note is published, and frame containing three portraits taken at different periods of his life, is hung on the Society's walls in furtherance of a suggestion made by the writer of this note in the Journal of this Society, Vol. XLVI, p. 17.

2. Model showing the Orbit of the present Comet (Westphal), in relation to the Sun and Earth, by Professor W. E. COOKE, M.A.

ABSTRACT OF PROCEEDINGS, DECEMBER 3rd, 1913.

The three hundred and sixty-third (363rd) General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth-street North, at 8 p.m.

Mr. H. G. SMITH, President, in the Chair.

Twenty-three members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of candidates for admission as ordinary members were read: one for the second, and two for the first time.

Mr. L. HARGRAVE and Dr. G. HARKER were appointed Scrutineers, and Mr. R. H. CAMBAGE deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

A. H. Martin, Teacher, Architecture Department, Sydney Technical College.

It was announced that 3 volumes, 108 parts, 6 reports, 1 map and 1 catalogue were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "On a new species of Eucalyptus from Northern Queensland," by J. H. Maiden, F.L.S. and R. H. Cambage, L.S., F.L.S.

2. "Notes on Eucalyptus, with description of new species," No. II, by J. H. Maiden, F.L.S.

Remarks were made by the President and Mr. R. H. Cambage.

3. "The occurrence of Trimethylamine and its origin in the Australian Salt-bush, *Rhagodia hastata* R. Br.," by R. W. Challinor, F.I.C., F.C.S.

This plant belongs to the family Chenopodiaceæ and is the common species grown in the gardens around Sydney. The investigation was carried out in order to locate, if possible, the constituents which give rise to the volatile substance having a strong herring-brine odour. Trimethylamine was obtained on distilling the fresh branchlets with caustic alkali, the amount obtained in this way being equivalent to 0·012 per cent. Analysis of the plant was undertaken by a method similar to that of Schulze, and a basic substance isolated, the hydrochloride of which decomposes at about 220° C. with evolution of trimethylamine. This salt resembles choline hydrcloride very closely in its chemical reactions, but differs from it in being non-deliquescent and considerably less soluble in absolute alcohol. The double platinum salt contains 30·68 per cent. of platinum

whereas the platinum salt of choline contains 31·65 per cent. The platinochloride, crystallised from water over sulphuric acid, consists of anhydrous orange coloured plates and prisms and melts at 217 – 218° C. (uncorr.) with decomposition; according to Henry, "The Plant Alkaloids," choline platinochloride melts at 215 – 240° C. with decomposition. This basic substance, the hydrochloride of which crystallises in monoclinic crystals, is thus apparently the parent substance from which the trimethylamine is obtained.

Remarks were made by Mr. MAIDEN, Prof. ROBINSON and the President.

EXHIBITS:

1. Acid Silica Gels, by W. J. CLUNIES ROSS, B.Sc.

Specimens were exhibited to show the power of a small quantity of a solution of silicate of soda to gelatinize a large quantity of various acids. Gels were shown produced by hydrochloride, sulphuric, nitric, acetic, phosphoric, tartaric, oxalic and formic acids. Also gels coloured by copper, iron, manganese and cobalt respectively.

2. Mr. R. T. BAKER exhibited old wooden water pipes from London and Sydney. Remarks were made Mr. L. HARGRAVE.

APPENDIX.

Popular Science Lecture, "Irrigation in India and in Egypt."

By Professor W. H. Warren, LL.D.

(Delivered in the Society's Hall, October 16th, 1913.)

Introductory.

Irrigation is of very ancient origin, and it appears to have been practised in Mesopotamia and Egypt several thousand years before the Christian Era. The earliest form was probably a natural inundation system brought about by rivers overflowing their banks and flooding the lands bordering on their lower reaches. This appears to have been the origin of the Basin System which has been so largely practised in Egypt and which, in the time of Joseph, made it the principal producer of corn for the adjoining countries.

Rivers such as the Nile in Egypt and those in Northern India having seasons of periodic flood, generally have their source in mountain ranges where the rainfall is heavy and the formation rocky. The stream is at first torrential in character, and flows rapidly down the steep slopes carrying with it material eroded from its bed and the sides of the valley in which it flows. The slope becomes less steep and the velocity less rapid as it approaches the foot of the hills where the heavier material carried in suspension is deposited. The river flows in a more or less deep channel through the flatter country in its course towards the sea, gradually diminishing in velocity and increasing in width until it reaches at length the region where it overflows its banks in times of flood. The material hitherto carried in suspension is deposited, gradually raising the level of the bed and banks and spreading its silt on the adjacent lands.

The object of the basin system is to control and regulate these periodic inundations, and consists of forming a chain of basins on the land bordering on the river by constructing suitable embankments, regulators and canals.

Some such system of control may have been applied to the Tigris and Euphrates in Mesopotamia, but the great prosperity and fertility of Babylonia appear to have been due to a more advanced system of irrigation. According to the Bible, and to a record said to be older, it appears that Hammurabi, one of the kings of Babylonia, made a canal and constructed branch canals distributing the water over the desert plains. The inscription describing these ancient works existed 2200 B.C., and it states that the water supply was unfailing, thus implying that the canals were what we now call perennial.

So that the system of perennial canals which has been so successfully introduced into India by British engineers probably owes its origin to the hydraulic engineers of ancient Chaldea.

Irrigation in India.

It appears that far back in ancient history man has devised many systems for carrying water to land under cultivation in order to increase the fertility of the soil, and in no country is this ancient system of irrigation better exemplified than in India.

The Hindu races were probably mainly responsible for the introduction of irrigation in India, and the extent to which it was and is still practised, is governed by the deficiency or abundance of the rainfall and the supply of water carried by the rivers and water courses of the country. The methods resorted to by the natives of India for obtaining water for irrigation purposes were by means of wells, storage tanks, and inundation canals derived from rivers. An inundation canal can only be supplied with

water when the river is in flood; it has no regulating devices for controlling the supply, so that its utility depends upon the fixed volume, regular periodicity and duration of the river floods. These canals, together with wells, were the only means of irrigation available in ancient times in the Punjab and Scinde. In the southern district of the Madras Presidency, where the rainfall is small and uncertain, an enormous number of artificial reservoirs or tanks has been constructed for the storage of water, many of these are of great antiquity. According to Colonel F. H. Rundall, c.s.i., r.e., about 60,000 of these tanks are provided with masonry works. The Madras tanks depend mainly on local rainfall, but they are sometimes supplied from rivers or streams by means of channels taking off above weirs constructed in the beds of rivers. In a Government Report it is stated that there are 1129 weirs across rivers or streams in Madras, each connected with a series of tanks, or with a single one. The larger weirs of irrigation works, such as the delta systems, are not included in the numbers stated.

The natives of India appear to have possessed considerable skill in the construction of embankments of earth for forming tanks and anicuts across rivers, which, although developed to a greater extent in Madras, existed more or less in other parts of India. In the tract of land between the Ganges and the Jumna, now commanded by the Ganges Canal, there existed, in 1860, 70,000 masonry wells, and 280,000 temporary earthen ones, irrigating 1,470,000 acres by lift. Some of these are still in existence. Again, in many of the larger rivers are to be found the remains of ancient anicuts or weirs of somewhat crude construction, but generally well located in regard to the purpose intended. Some of these have been restored and are still in use, but the annual cost of repairs is excessive. Hence it is clear

that irrigation in India is of ancient origin, and it was necessary for the British engineers in the first place to study the works they found in that country, and the conditions which influenced their efficiency, before they could apply successfully their greater skill and scientific knowledge to the design and construction of those greater irrigation works now so widely distributed throughout the Indian Empire.

Mechanical Appliances for Raising Water.

The ancient methods used by the natives of India and Egypt for raising water from wells and low-lying depressions consist of the following:—

1. The Persian Wheel. 2. The Mote. 3. The Picottah in India (called the Shadouf in Egypt). 4. The Basket. 5. The Doon.

All along the banks of the Nile one sees the numerous shadoufs at work lifting water from the river into channels leading to the areas under cultivation. The Persian Wheel is called a sakia in Egypt, and is generally actuated by bullocks. These ancient and somewhat crude devices have been used for raising water in India and Egypt for thousands of years, and they are apparently just the same to-day.

In Egypt there is a considerable number of pumping plants used for lifting water and for drainage of the low-lying land on portions of the delta.

The method of obtaining water from rivers for irrigation consists of inundation and perennial canals. In regard to inundation canals the site for the entrance taking off from the river should be carefully selected, the object being to reduce the deposit of silt in the canals and convey as much of it as possible to the lands to be irrigated, as the deposits from the flood waters of silt-bearing rivers are most valuable fertilizing agents.

In the almost rainless districts of the Punjab and the Scinde in India, considerable areas of land are irrigated by numerous inundation canals derived from the Indus and its tributaries.

Perennial canals supply the areas irrigated, not merely in flood time, but whenever necessary, enabling the district to be more fully cultivated and with greater certainty than would be possible by the intermittent system of inundation canals.

There are two types of perennial canals:—

(*a*) Those which draw their supplies from the upper portions of rivers and convey the water to the lower parts of their valleys, frequently over long distances.

(*b*) Those which start from a deltaic river at the head of the delta and irrigate the low-lying lands lying between, and for some distance on the other side of the diverging branches of the river.

Examples of the first kind in India are:—The Upper Ganges Canal system taking off the river at Hardwar; the Lower Ganges Canal systems taking off at Narora lower down the river; the Agra Canal taken from the right bank of the Jumna at Okla about eight miles below Delhi. These are in the United Provinces of Agra and Oudh.

In the Punjab there are some fine examples of perennial canals, including the following:—The Bari Doab Canal taking off the upper portion of the Ravi at Madhopur; the Chenab Canal irrigating the Rechna Doab between the Ravi and the Chenab, taking off at Khanke a few miles below Wazirabad; the Sidhnai Canal taking off the lower portion of the Ravi near its junction with the Chenab, which is partially perennial.

Examples of the second kind, which start from the head of deltaic rivers, occur in the Province of Madras as Dow-

laishwaram, near Rajahmundry, at the head of the Godavery Delta; the Kistna system of canals taking off at the head of the delta at Bezwada; the Cauvery system of canals taking off the rivers Coleroon and Cauvery near Trichinopoli; the canals taking off just above the Delta Barrage in Egypt, which irrigate the delta.

The foregoing systems of perennial canals are fine examples of their kind, and they will be mainly considered in regard to their efficiency in supplying water to irrigate the land under cultivation. They are all artificial channels supplied from rivers giving an ample supply of water, and are separated into branches, each of which is provided with major or minor channels supplying directly the water courses connected with the irrigated areas. Great care is necessary in designing these canals in order that they may fulfil their purpose efficiently and economically, and the proper site and nature of the head works are of the greatest importance.

The head works consist of a weir across the river provided with under sluices. The entrance to the canal is through head sluices for regulating the supply of water. The main objects of a weir across the river are to raise the level of the water in the dry season, when the river is low, and to provide a means of forcing it through the head sluices of the canal. The under sluices, which are constructed in the weir itself, are necessary to create a scour during the flood season to keep a definite channel open above the weir in the neighbourhood of the canal head, so that there may be no difficulty in leading the water to the head sluices when the river is low.

In India weirs are divided into six classes:—1. Founded on rock. 2. In the boulder formation at the head of rivers near the hills. 3. In clay or kunkur soils. 4. On sand overlying clay or rock which can be reached in a reasonable

depth. 5. On coarse sand of very great depth. 6. On fine sand of very great depth.

The perennial system in Egypt has been rendered possible by the construction of the Assûan Dam, which has been thickened and heightened recently so as to provide a storage of about 2,420,000 cubic metres of water. All the flood waters of the Nile pass through the sluices of this great dam, and during the months extending from November to March the sluices are closed and the reservoir filled. During the months of April, May, June and part of July the reservoir is drawn upon to supplement the deficient discharge of the river. Extensive areas of the basin system have been converted to the perennial system, producing two crops a year, with considerable advantage to the prosperity of Upper Egypt. Two important river regulators have been built between Assûan and Cairo. The Assiût Barrage, which is constructed just below the head works of the Ibrahimia Canal, and the Esna (or Isna) Barrage between Luxor and Assûan. The Assiût Barrage has been built across the Nile to regulate the supply of the Ibrahimia Canal, and it is designed to hold up a head of 2·55 metres. The Ibrahimia Canal head is designed to withstand a head of 3·25 metres.

The Assuan Dam.

This great work is build across the Nile at the first cataract. The dam is 6,400 feet long, or about 1¼ miles. As stated in a report by the Director-General of Irrigation Works in Egypt, Mr. MURDOCK MACDONALD, C.M.G., M.Inst.C.E., there were three distinct phases in the construction of this dam, as it now stands. (1) The building of the original dam; (2) the protection of the rock faces down stream, and (3) the thickening and heightening of the dam.

As originally built the height was only 85 feet, and the area impounded 863,000 acre feet. This work is principally

remarkable as being the only solid dam which passes the discharge of a large river like the Nile through its body, for which purpose it is provided with 140 low-level sluices, each 23 feet deep by $6\frac{1}{2}$ feet wide, and 40 upper sluices $11\frac{1}{2}$ feet deep by $6\frac{1}{2}$ feet wide. The lower sluices were designed to be capable of passing the largest possible flood with a relatively small head of water on the up-stream side of the dam. The upper sluices were built for the purpose of discharging under low heads the normal river when the reservoir is full.

The Government of Egypt, in consequence of antiquarian agitation regarding the temples of Philæ, agreed not to build the dam higher than 85 feet (106·00 R.L.) which produced a volume of 980,000,000 cubic metres, as this height, while submerging some of the outer works and colonnades of Philæ, left the main temples high and dry. The requirements of Egypt, however, were not fully met by the original dam and it became absolutely necessary to provide additional storage-area.

When the dam was originally under construction the temples on the island of Philæ were, where necessary, carefully underpinned down to solid rock, and although the depth of water about these temples is increased by seven metres, there appears to be no reason to doubt their stability. A few other temples of minor importance in Nubia will be affected by the increased depth of water in the reservoir.

Before proceeding with the thickening and heightening of the dam it became necessary to strengthen the aprons on the down-stream side in order to resist the erosion of the granite bed of the river immediately below the dam. The effect of such an enormous volume of water flowing through the sluices at a high velocity has rendered necessary the construction of a heavy masonry floor set in 2 to 1

cement mortar, and at present the work is satisfactory and likely to remain so. The thickening and heightening of the dam were begun after the talus or apron had been completed. Sir BENJAMIN BAKER came to the conclusion that the only satisfactory method of building the thickening in contiguity to the old dam, so as to form the whole into as homogeneous a structure as rubble masonry built in such a climate would permit, was to keep the old and the new parts separate until such time should elapse as might permit of the new work reaching the same temperature stage as that of the old part, when the space between could be filled with cement grout consisting of 1 of water to 1·2 of Portland cement.

The Grand Barrage, or Delta Barrage as it is more frequently called, is situated at the head of the delta north of Cairo. It was originally built by a French engineer, M. MOGEL, but it failed to hold up even a moderate head of water. The failure was due to careless construction rather than to the design. It consists of two separate works across the heads of the two branches of the river—the Damietta and the Rosetta. There are three main canals which take off above the barrage, which with numerous branches irrigate the delta. The restoration of this great work was undertaken by Sir J. FOWLER and Sir B. BAKER and consisted in lengthening the aprons of masonry up and down stream, covering the old floor with a layer of concrete 4 feet thick over which was laid a pavement of ashlar masonry under the arches and over a portion of the down-stream apron; also a row of piles was added to the up-stream apron. The foundations of the barrage were further consolidated by means of cement grout under pressure. By means of these additions the barrage was able to hold up 4 metres, but it was decided to reduce this to 3 metres, and subsidiary weirs were con-

structed on both branches of the river below the barrage which hold up $3\frac{1}{2}$ metres, or the total head held up was $6\frac{1}{2}$ metres. In this way more perfect control has been obtained over the water at the apex of the delta during all seasons. The Menufia regulator, at the head of the Central Canal, is a fine specimen of its kind.

The Zifta Barrage, built across the Damietta branch, is a typical example of a river regulator, and embodies the experience gained in the construction of similar works elsewhere.

The United Provinces of Agra and the Oudh, the Madras Presidency, and also the Punjab in India furnish some manificent examples of irrigation works.

In the former the Ganges upper and lower systems of perennial canals are the most important. The Upper Ganges Canal takes off just above the sacred town of Hardwar, where the river emerges from the Sewalic Hills at the foot of the Himalayan Mountains. The Lower Ganges takes off at Narora where a fine weir has been constructed.

On both systems of canals there are many very interesting works, such as the Ranipur and Puthri super passages for passing mountain torrents across the canal, the Solani Aqueduct carrying the canal across the Solani Valley, the Dhanauri level crossing. All these are on the Upper Ganges system. On the Lower Ganges Canal there is a remarkably fine aqueduct called the Kali Nadi, or Nadrai.

The most modern and one of the finest of the great perennial systems is the Chenab Canal which irrigates the country known as the Rechna Doab between the Ravi and the Chenab rivers. A weir has been constructed across the Chenab at Khanke 4,000 feet long, with very fine under-sluices which keep the channel clear in front of the head works of the canal. The canal has a full discharge of

10,800 cusecs. or more than ten times that of the main canal at Berembed on the Murrumbidgee. The area irrigated is 2,000,000 acres, and the population supported is 1,000,000. The training works on the Chenab River are on a grand scale and represent the system of river training adopted in the Punjab. The Bell-bunds on the Chenab and the tee-headed groins on the Ganges are worthy of careful study.

In Southern India the Delta systems are the most interesting, and all these, with the exception of the Mahanadi in Orissa, are situated in the Madras Presidency. The essential distinction between the ordinary conditions of Northern and Southern India is that in the north there is a perennial supply fed from the melting snows of the Himalayan Range, restricting the area under cultivation by a fixed and more or less limited supply of water, whereas in the south the main crops are grown at the time when the rivers are at their maximum volume, and frequently the south is subjected to drought. Throughout the whole Madras Presidency, in every valley, some arrangements exist for the conservation of water, which is utilized to the last drop.

The principal Delta systems are the Godavery and Kistna, lying between Coconada and Pedda Gangan on the east coast; they adjoin one another and form an extensive and connected irrigation area about 200 miles long by 50 miles wide. Both the Godavery and Kistna rivers break through the line of the Eastern Ghats within fifty miles of the sea, and in the course of ages have built up the wide stretch of delta lands beyond them.

The head of the Godavery Delta is at Dowlaishwaram, about four miles from the railway station, Rajahmundry. A weir designed by Sir ARTHUR COTTON has been constructed across the river where the total width from bank

to bank is three and a half miles, but four islands reduce the length of the weir to two and a half miles. The river Godavery drains 115,570 square miles, and has a maximum discharge of over 1,000,000 cusecs. The rise of flood at the weir is 27 to 28 feet; the bed of the river is pure sand.

At the head of the Delta there are four channels; of these the two eastern ones unite again almost immediately and form what is called the Gowtami-Godavari; and the two western channels similarly unite to form the Vasista-Godavari. The land between these two principal branches forms the central delta, and that lying to the east of the Gowtami-Godavari forms the Eastern Delta; also the land lying to the west of the Vasista-Godavari forms the Western Delta.

The weir is 14 feet in height, and the three sets of head sluices give a total area of 654¾ square feet. The development of the various canals and distributary channels in the three sections of the delta was undertaken gradually, and to-day the system is one of the largest and most successful in India, returning over 20% on the capital invested.

The Kistna Delta system was designed by Sir Arthur Cotton soon after the construction of the Godavari Weir. The Kistna Weir is about 3,000 feet long, with a total length of 4,000 feet, including the under sluices, and is constructed at a narrow portion of the river where a spur of sandstone runs down to the bed of the river at each side of the weir. The site for the weir was selected on account of the excellent supply of good stone immediately available from the rocky hills on each side. On each flank of the weir scouring sluices are provided in order to keep a clear channel in front of the regulating sluices of the two main canals where they take off. The flood waters rise nearly 20 feet above the weir crest with a velocity of eleven miles an hour.

The Kistna Canals have a total length of main line and branches of 325 miles, of which 284 miles are navigable. There are 1,614 miles of distributing channels commanding 800,000 acres. Like that of the Godavari, this system gives exceedingly good financial returns. The various head works to the canals, and the under sluices in the river in the Godavari and Kistna systems are excellent examples of their kind. There are some fine examples of under sluices at Shahatope Anicut.

The most interesting reservoir scheme of irrigation in India is the Periyar system in Madras. This work was designed to irrigate the district of Madura, in Southern India, where the rainfall is scanty and uncertain, and where famines have frequently occurred. This district was formerly watered by the river Vaigai, which draws its supply from a catchment area on the eastern side of the Ghats, and irrigation has been in operation from time immemorial. On the western side of the Ghats the rainfall is copious and secure, but it passed down the Periyar Channel to the sea unutilized.

On one portion of the course of the Periyar it is only a few miles from one of the tributaries of the Vaigai, and the project consisted in diverting the surplus waters of the Periyar through the hills which intervene between it and the Vaigai. A reservoir was constructed by Colonel PENNYCUICK, R.E., by means of a concrete dam 1,241 feet long and 155 feet in height, a tunnel cut in rock through the intervening hills 5,704 feet long, having a cross-sectional area of 90 square feet and a fall of 1 in 75, discharges the water into the tributary of the Vaigai.

GEOLOGICAL SECTION.

ABSTRACT

OF

PROCEEDINGS OF THE GEOLOGICAL SECTION.

Monthly Meeting, 9th April, 1913.

Prof. T. W. E. David, in the Chair.

Ten members and two visitors were present.

On the motion of Mr. R. H. Cambage, seconded by Mr. C. Hedley, Professor David was re-elected Chairman for the current year. On the motion of Dr. C. Anderson, seconded by Mr. L. Cotton, Mr. C. A. Sussmilch was re-elected honorary secretary.

After discussion the following subjects were recommended for discussion during the year :—(*a*) The strata of unknown age which encircle the Triassic basin of the Clarence River District. (*b*) The geological age of the Clarence River Series. (*c*) The geological age of the alkaline volcanics of the Northern Rivers District. (*d*) The Ordovician and Silurian formations of the Bodalla District. (*e*) The Cooma Metamorphic Series. (*f*) Age of the last orogenic movements which effected New South Wales other than the New England District. (*g*) The age of the Tertiary alkaline rocks and their relation to lines of Tertiary faulting. (*h*) Joint systems and their aid in determining relative ages of adjoining formations.

Dr. C. Anderson moved that the Section take up the question of supplying the necessary data for the International Science Catalogue regarding geological and mineralogical papers published in N. S. Wales, and it was agreed that the following members be nominated to the

Council of the Royal Society for this work:—1. Dr. C. ANDERSON for Mineralogy; 2. Mr. W. S. DUN for general geology and palæontology; 3. Mr. C. A. SUSSMILCH for petrology.

Mr. C. HEDLEY then delivered an address on former land connections between Antarctica and Australia. His conclusion was that the Arctic forms of our present fauna and flora did not arrive into Australia until the Glacial Epoch, and that therefore the land connection must have existed until at least the period of maximum glaciation.

Monthly Meettng, 21st May, 1913.

Prof. T. W. E. DAVID, in the Chair.

Six members and three visitors were present.

Mr. E. C. ANDREWS exhibited a specimen of contorted slate from Canbelego, N.S.W.

Mr. C. A. SUSSMILCH gave a description of some of the physiographical features of Eastern Victoria. He pointed out that the general physiographical features were similar to those of South-eastern N.S. Wales, that block-faulting had taken place on a large scale, and that many of the fault-blocks were tilted.

Messrs. E. C. ANDREWS, R. H. CAMBAGE and Prof. T. W. E. DAVID also spoke on the subject.

Monthly Meeting, 11th June, 1913.

Mr. W. S. DUN, in the Chair.

Nine members and three visitors were present.

Mr. E. C. ANDREWS gave an outline of the results of his geological survey of the Cobar District. He described the physiography, general geology, and petrography of the area and gave a detailed description of the ore-deposits. His remarks were illustrated with maps and sections and a large collection of rocks and minerals.

Monthly Meeting, 9th July, 1913.

Prof. T. W. E. DAVID, in the Chair.

Eight members and five visitors were present.

A discussion took place as to the geological age of the last orogenic (folding) movements which had effected the state of N. S. Wales other than the New England District. The discussion was opened by Mr. C. A. SUSSMILCH, who outlined the known evidence, particularly that occurring on the western and southern margins of the main coal basin, and gave as his opinion that a great orogenic movement took place at or near the close of the Upper Devonian Epoch.

Prof. DAVID referred more particularly to evidence from the northern margin of the Permo-Carboniferous coal basin and was of opinion that the Upper Devonian stata were not folded until the end of the Carboniferous Period.

Messrs. W. S. DUN and L. F. HARPER also spoke on the discussion, but no definite conclusion was arrived at.

Monthly Meeting, 13th August, 1913.

Prof. T. W. E. DAVID, in the Chair.

Eight members and seven visitors were present.

Mr. W. S. DUN exhibited some recent geological publications relating to Egypt, Indo-China, and the United States.

Mr. G. W. CARD exhibited the following specimens:—Native silver, C.S.A. Mine, Cobar; torbernite, Carcoar, N.S.W.; cervantite, Barellan, N.S.W.; joseite, Mount Shamrock Mine, Queensland; meteorite (new), Molong; vein of native bismuth in wolfram, Torrington; topaz, Rock Vale.

Mr. L. F. HARPER exhibited a relief model of the Illawarra District, showing the geological formations and gave a summary of the results of his geological survey work in

that district. His remarks were illustrated with a large number of rock specimens.

Monthly Meeting, 8th October, 1913.

Mr. J. E. CARNE, in the Chair.

Seven members and two visitors were present.

Prof. DAVID was absent owing to illness in his family.

Mr. R. H. CAMBAGE exhibited a specimen of granite from Bellenden Ker Mountain, Queensland, and some photographs of the Upper Cretaceous strata in the same State.

Mr. G. W. CARD exhibited a number of specimens of miniature faults occurring in a tuff from Pokolbin. He also exhibited a new geologist's slide-rule.

Mr. F. WATKIN BROWN exhibited a peculiar ironstone concretion shaped like an eel from the Wianamatta Shales at Enfield near Sydney.

Monthly Meeting, 12th November, 1913.

Prof. T. W. E. DAVID in the Chair.

Seven members and six visitors were present.

The Chairman, on behalf of the members, welcomed Mr. W. ANDERSON of the Geological Survey of Natal and formerly of the Geological Survey of N.S. Wales.

Dr. C. ANDERSON exhibited specimens of wind-worn pebbles (Dricanter) from Wanganui, N.Z.

Mr. G. W. CARD exhibited native bismuth, and bismuthmite from Kingsgate, N.S.W. Wolfram altering into tungstite from Wolfram, N.S.W. Sill-rock with fossil *Glossopteris* from Helensburgh. N.S.W.

The Chairman opened a discussion on "The effect of prevalent winds in controlling land forms." He referred particularly to the effect which the prevailing westerly winds must have had in the different geological periods in influencing the positions of maximum sedimentation.

INDEX.

F. W. WHITE, 344 Kent St., Sydney.

J

Plate I.


QUEENSLAND
SOUTH AUSTRALIA
NEW SOUTH WALES
THE INTERIOR
WESTERN SLOPES
MOUNTAIN REGION
COASTAL AREA
VICTORIA
TASMANIA
SOUTH PACIFIC OCEAN
TASMAN SEA
BASS STRAIT
Boggabilla
Mungindi
Moree
Warialda
Tenterfield
Emmaville
Glen Innes
Inverell
Bingara
Tabulam
Lismore
Casino
Byron Bay
Grafton
Armidale
Brewarrina
Bourke
Walgett
Narrabri
Barraba
Manilla
Boggabri
Tamworth
Louth
Byrock
Tarella
Tilpa
Myall
Wilcannia
Broken Hill
Silverton
Menindee
Mt. Drysdale
Cobar
Coonamble
Coonabarabran
Werris Ck.
Kempsey
Port Macquarie
Nyngan
Warren
Gilgandra
Murrurundi
Coolah
Scone
Muswellbrook
Forster
Dungog
Mudall
Dandaloo
Nymagee
Bodadah
Narromine
Dubbo
Wellington
Mudgee
Gilgunnia
Double Peak
Mt. Hope
Peak Hill
Rylstone
Cudgegong
Singleton
Maitland
Newcastle
Euabalong
Condobolin
Trundle
Parkes
Molong
Mullion Creek
Bogan Gate
Forbes
Orange
Bathurst
Blayney
Cargo
Hillston
Cowra
Rockley
Oberon
Katoomba
Broken Bay
Port Jackson
Sydney
Wyalong
Marsden
Grenfell
Trunkey
Tuena
Wentworth
Barmedman
Temora
Koorawatha
Boorowa
Bulli
Balranald
Hay
Ardlethan
Young
Harden
Crookwell
Goulburn
Kiama
Narrandera
Cootamundra
Yass
Junee
Nowra
Jervis Bay
Gundagai
Lake George
Wagga
Tumut
Adelong
Queanbeyan
Braidwood
Deniliquin
Jerilderie
Berrigan
Finley
Culcairn
Germanton
Batemans Bay
Corowa
Albury
Kiandra
Moama
Cooma
Mt. Kosciusko
Bombala
Eden
Twofold Bay
Cape Howe
Darling River
Barwon River
Bogan River
Macquarie River
Castlereagh River
Namoi River
Gwydir Riv.
Macintyre River
Lachlan River
Murrumbidgee River
Murray River
Hunter River
Manning Riv.
Macleay R.
Shoalhaven River
Indi R.
Snowy R.
From Adelaide
To Brisbane
Bendigo
Seymour
Mt. Hotham
Omeo
Ararat
Daylesford
Ballarat
Glenelg River
Wannon R.
Wannon
Melbourne
Port Phillip
Berwick
Mornington
Sale
Bairnsdale
Cape Otway
Wilsons Promontory
Mt. Bischoff
Burnie
Launceston
Macquarie Harbour
Hobart
141°
144°
147°
150°
153°
30°
33°
36°
39°
42°
To Illustrate Presidential Address (1913) by R. H. Cambage L.S., F.L.S.
Scale of Miles
50 40 30 20 10 0 50 100 150
Authors route .... Vide Proc. Lin. Sc.y N.S.W. 1900-1902
Railways shown thus ———

Angophora Seedlings—(Reverse Side).

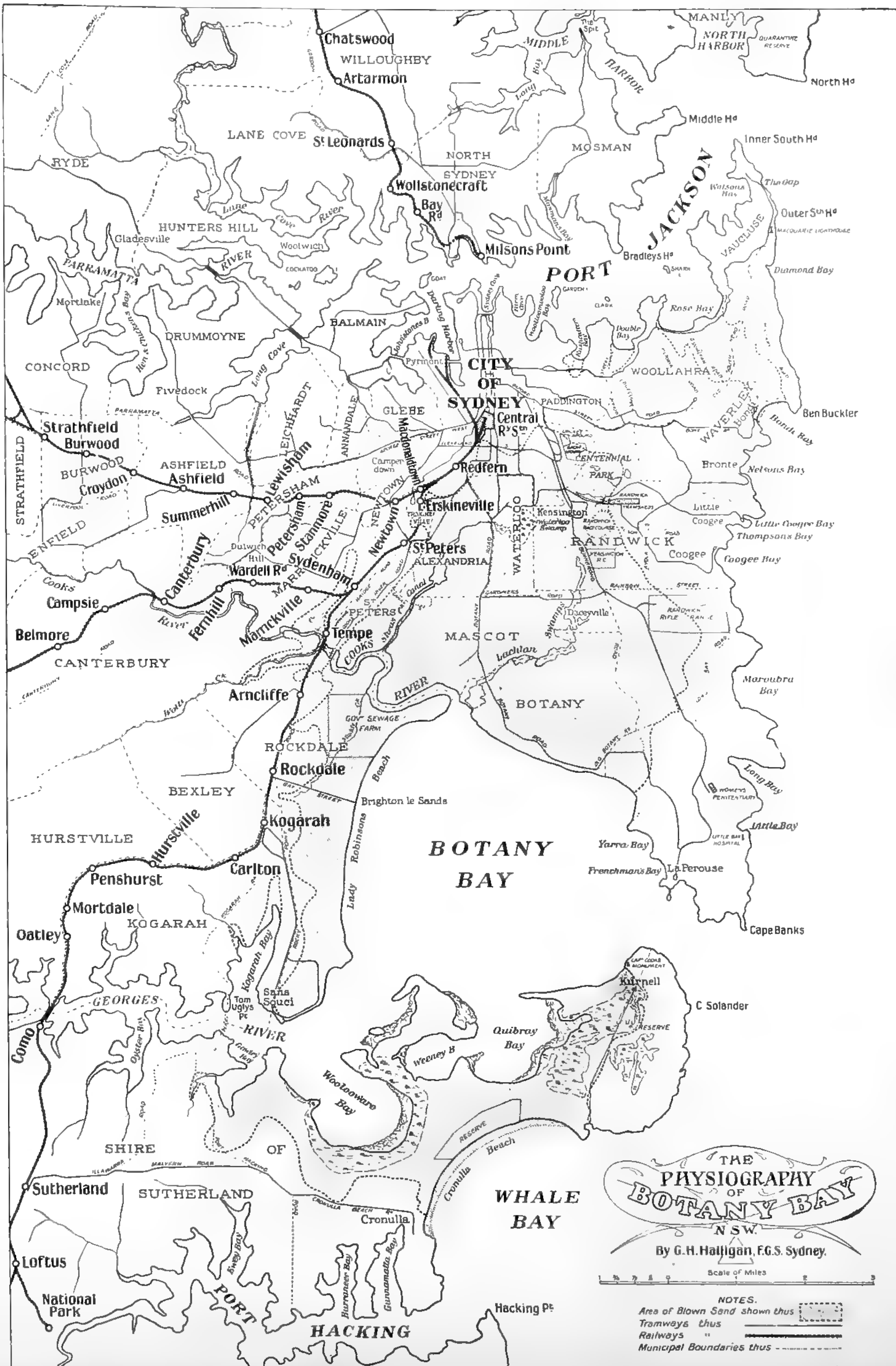
1. *Angophora intermedia.* 2. *Angophora subvelutina.* 3. *Angophora cordifolia.*

Angophora Seedlings—(Reverse Side).

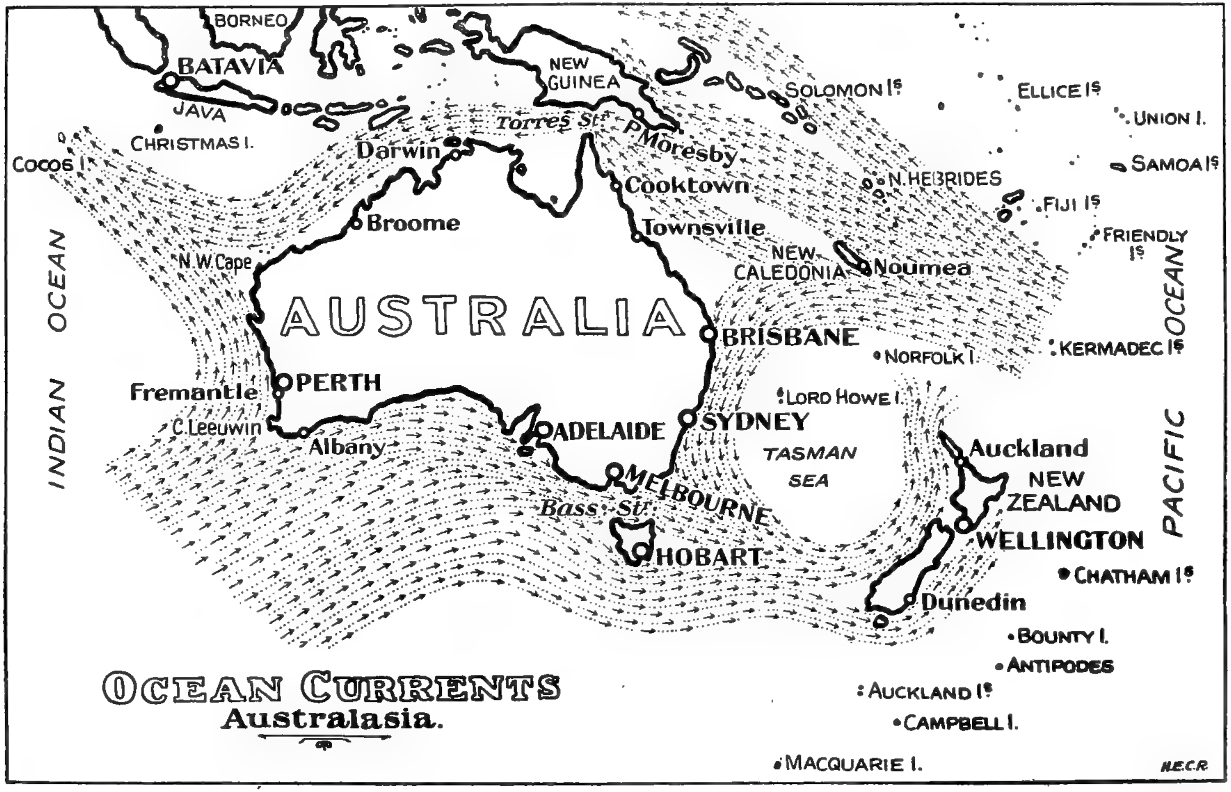
1. *Angophora melanoxylon.* 2. *Angophora Bakeri.* 3. *Angophora lanceolata.*

R.T.B. del.

ANGOPHORA BAKERI. *sp. nov.*


THE
PHYSIOGRAPHY
OF
BOTANY BAY
N.S.W.
By G.H. Halligan, F.G.S. Sydney.
Scale of Miles
NOTES.
Area of Blown Sand shown thus
Tramways thus
Railways "
Municipal Boundaries thus
H E C Robinson Delt Sydney
BOTANY
BAY
WHALE
BAY
PORT
JACKSON
CITY
OF
SYDNEY
PORT
HACKING
Chatswood
Artarmon
St Leonards
Wollstonecraft
Milsons Point
Strathfield
Burwood
Croydon
Ashfield
Summerhill
Lewisham
Petersham
Stanmore
Newtown
Erskineville
Redfern
St Peters
Sydenham
Marrickville
Tempe
Canterbury
Campsie
Belmore
Arncliffe
Rockdale
Kogarah
Carlton
Hurstville
Penshurst
Mortdale
Oatley
Como
Sutherland
Loftus
National Park
Cronulla
Kurnell
La Perouse
Cape Banks
C Solander
Hacking Pt
Ben Buckler
Bronte
Coogee
Randwick
Mascot
Botany
Waverley
Woollahra
Paddington
Mosman
Manly
North Harbor
North Hd
Middle Hd
Inner South Hd
Outer Sth Hd
Bradleys Hd
Balmain
Drummoyne
Concord
Ryde
Hunters Hill
Lane Cove
Gladesville
Glebe
Alexandria
Waterloo
Kensington
Brighton le Sands
Lady Robinsons Beach
Georges River
Cooks River
Parramatta River
Quibray Bay
Weeney B
Woolooware Bay
Kogarah Bay
Sans Souci
Cronulla Beach
Shire of Sutherland
Long Bay
Little Bay
Maroubra Bay
Coogee Bay
Bondi Bay
Yarra Bay
Frenchman's Bay
Rose Bay
Double Bay
Dulwich Hill
Fernhill
Wardell Rd
Enfield
Bexley
Daceyville
Centennial Park
Mortlake
Fivedock
Gov. Sewage Farm
Tom Uglys Pt

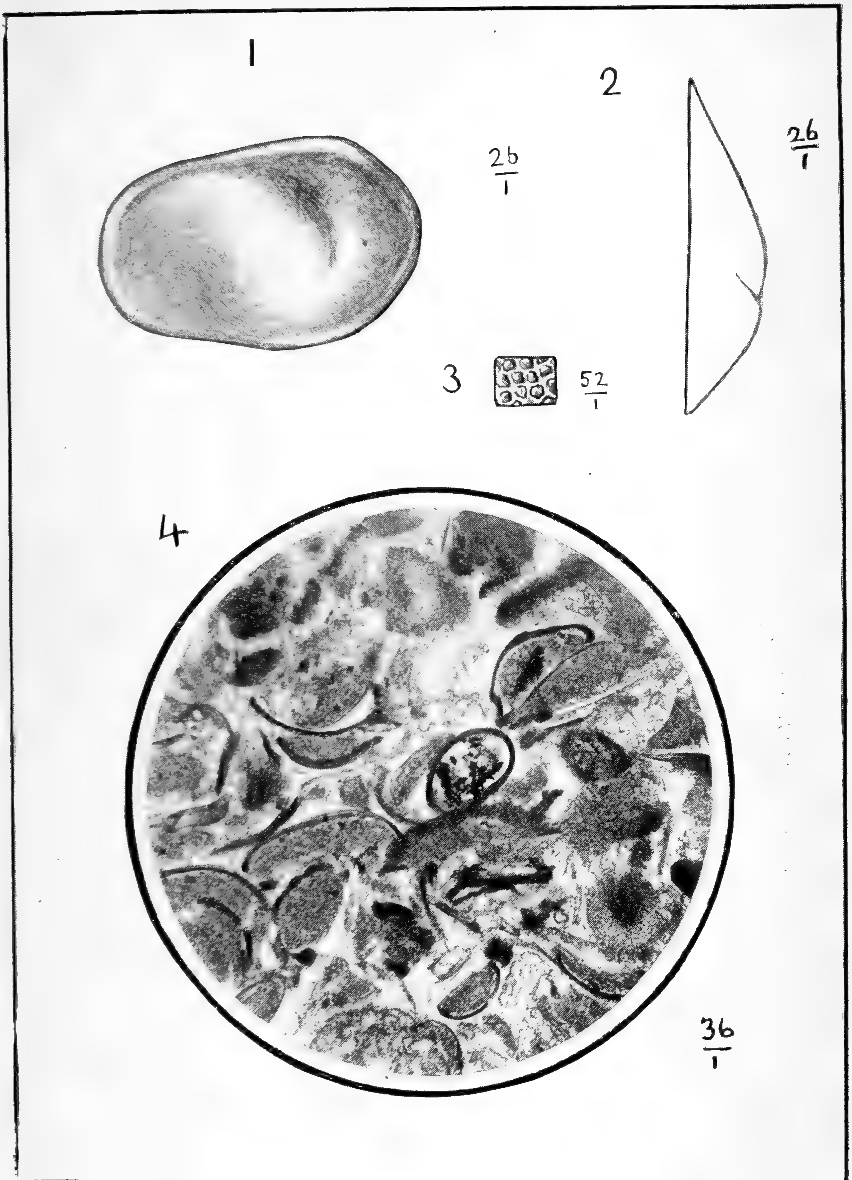

EA
SOLOMON Is
ELLICE Is
UNION I.
SAMOA Is
P. Moresby
Cooktown
N. HEBRIDES
FIJI Is
Townsville
FRIENDLY Is
NEW CALEDONIA
Noumea
OCEAN
LIA
BRISBANE
NORFOLK I.
KERMADEC Is
LORD HOWE I.
SYDNEY
LAIDE
PACIFIC
TASMAN SEA
Auckland
MELBOURNE
NEW ZEALAND
St.
WELLINGTON
HOBART
CHATHAM Is
Dunedin
BOUNTY I.
ANTIPODES
AUCKLAND Is
CAMPBELL I.
MACQUARIE I.
H.E.C.R.



OCEAN CURRENTS
Australasia.

(Half Natural Size.)

Photograph by B. Daydon Jackson, from Linnæus' original specimen in London Linnean Society's Herbarium. Shows the word "Cajaepoeli," written by Linnæus himself, and below the measurement scale the words "*M. Leucadendron*, Linn., vera," (not shown on plate) written by Dr. Smith.



DEVONIAN OSTRACODA: New South Wales.

CONTENTS.